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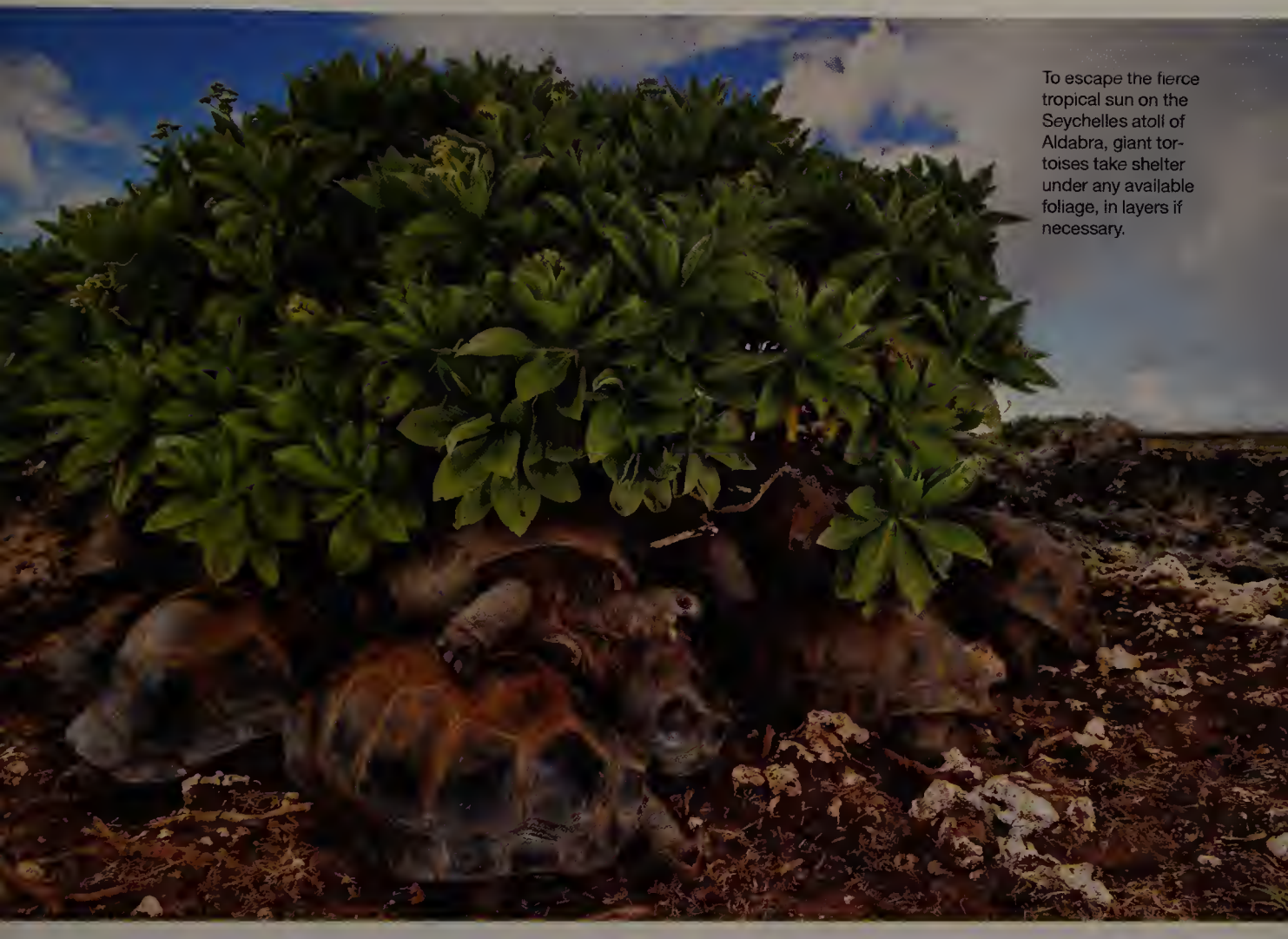
NATIONAL GEOGRAPHIC

MARCH 2016 • VOL. 229 • NO. 3



To escape the fierce tropical sun on the Seychelles atoll of Aldabra, giant tortoises take shelter under any available foliage, in layers if necessary.

82 **Return of the Seychelles**
Ecological restoration gives nature a second chance in this Indian Ocean island nation.
By Kennedy Warne Photographs by Thomas P. Peschak

30 **Waste Not, Want Not**
About a third of the planet's food goes to waste—some because it's not picture-perfect.
By Elizabeth Royte
Photographs by Brian Finke

56 **The Cold Rush**
With howling winds and subzero temperatures, even a melting Arctic is a brutal place to work.
By Joel K. Bourne, Jr.
Photographs by Evgenia Arbugaeva

102 **The Other Iraq**
Kurds in northern Iraq have created an oasis of prosperity and peace. Will ISIS destroy it?
By Neil Shea
Photographs by Yuri Kozyrev

124 **Proof | Tsunami Memories**
Survivors of Japan's 2011 tsunami pose amid remnants of their flooded-out lives.
By Jeremy Berlin Photographs by Alejandro Chaskielberg

On the Cover The large amount of U.S. food that's wasted includes produce that is "perfectly edible even if it's less cosmetically attractive," says the Natural Resources Defense Council. *Photo by Hans Gissinger*

Corrections and Clarifications Go to *ngm.com/more*.

Toss Less, Salvage More

The arugula tripped me up.

Like most of us, I try to be mindful of food that goes to waste. The arugula was to make a nice green salad, rounding out a roast chicken dinner. But I ended up working late. Then my husband did. Then friends called with an impromptu dinner invitation. I stuck the chicken in the freezer. But as days passed, the arugula turned to green goop. Even worse, I had unthinkingly bought way too much; I could have made six salads with what I threw out.

Carrots that grow through hard or rocky soil may become malformed but remain edible and nutritious.

In a world where nearly 800 million people a year go hungry, "food waste goes against the moral grain," as Elizabeth Royte writes in this month's cover story. It's jaw-dropping how much perfectly good food is trashed—from produce left to rot in the fields to "ugly" (but quite edible) vegetables rejected by grocers to massive amounts of uneaten, too big portions scraped into restaurant garbage bins.

Producing food that no one eats squanders the water, fuel, and other resources used to grow it. That makes food waste an environmental issue. In fact, Royte writes, "if food waste were a country, it would be the third largest producer of greenhouse gases in the world, after China and the U.S."

That's hard to get your mind around. So let's keep it as simple as that green goop at the back of my refrigerator.

Mike Curtin, Jr., sees my arugula story all the time—but for him, it's more like 12 pallets of donated strawberries nearing their last days. Curtin is CEO of DC Central Kitchen in Washington, D.C., which each week recovers about 15,000 pounds of food and turns it into healthy meals. DCCK finds this bounty everywhere. In fiscal year 2014 it recovered more than 807,500 pounds of food by taking donations, collecting misshapen and blemished produce, and gleaning at local farms where food otherwise would have rotted in fields. And the strawberries? Volunteers will wash, cut, and freeze or dehydrate them for use in meals down the road.

Such solutions seem obvious, yet so often we just don't think. "Everyone can play a part in reducing waste," Curtin says, "whether by not purchasing more food than necessary in your weekly shopping or by asking restaurants to not include the side [dish] you won't eat." I certainly can take both of those actions, can't you?

Thank you for reading *National Geographic.*

Susan Goldberg, *Editor in Chief*

For more tips on how to reduce food waste, check out our food blog, The Plate, at *theplate.nationalgeographic.com.*

PHOTO: HANS GISSINGER

Eastern Box Turtle *(Terrapene carolina)*
Size: Carapace diameter, up to 23.5 cm (9.25 inches) **Weight:** Up to 600 g (21 oz) **Habitat:** A variety of habitat types throughout the eastern U.S.A. **Surviving number:** Unknown; populations declining

Photographed by Todd Pusser

WILDLIFE AS CANON SEES IT

Slow going. Over the course of a lifetime as long as 80 years, the eastern box turtle does everything slowly. It lays eggs every other year and is content with a "slow food" diet that includes fruit, seeds, flowers, roots and grasses. This diet makes it an important seed disperser. When threatened, the turtle can seal itself away completely thanks to a hinge on the lower part of the shell, but even built-in protection is powerless against habitat loss, vehicle strikes and the pet trade. Populations are falling fast.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.

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Why I Fight for Education

When **Malala Yousafzai** was born, the people in her Pakistani village pitied her parents—she wasn't a boy. Now 18, Malala commands attention as the youngest ever Nobel Peace Prize winner. During her journey to the world stage, she took on the Taliban as an 11-year-old blogger, survived an assassination attempt, and co-founded the Malala Fund to support education around the world. *He Named Me Malala*, a film about her life, airs starting February 29 on the National Geographic Channel.

What would your life be like right now if you were living in Pakistan without an education?
I would have two or three children. I'm fortunate that I'm 18 and I'm still not married. When you don't get an education, your life is very much controlled by others. When there was terrorism and girls were stopped from going to school, my fear wasn't that I would be attacked for speaking out. My fear was that I would live a life in which I would not be able to be independent, to get an education, to be a doctor or a teacher or anything I wanted. I feared the life that many girls are suffering through right now.

What gave you the courage to speak up for girls?
My parents were always there to say that I have this right to speak, I have this right to go to school. If other girls in the Swat Valley, including some of my very close friends, had been given this right by their families, we would have been here together speaking out for girls' right to go to school. What I really mean is that I'm not a special girl who was different than others. There were many girls who were there, who could speak out better than me, who were more forceful than me. But no one allowed them.

What can other kids do?
I consider myself very lucky to be on this platform where I can be the voice of the 60 million girls who are deprived of education, but I think it's very important that children and kids think that their voices are powerful. It does not matter what your age is. We should believe in ourselves. If we want the future to be better, we need to start working on it right now. Children are in the millions in this world. If millions of children come together, they could build up this strong army, and then our leaders would have to listen to us.

PHOTO: JOHN RUSSO

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VISIONS

Japan
Sunset paints the sacred Meoto Iwa ("wedded rocks") in pastel hues. Bound by heavy rice-straw ropes, the two stacks off the coast of Futami—Izanagi (left) and Izanami—symbolize the Shinto deities said to have created Japan.

PHOTO: DAVIDE LENA

China
Frigid meets florid in a garden in Hami, where a blooming tree, watered the night before, dangles ice during a two-day cold snap in April. This cold-tolerant species will survive to bloom next year, but the plunge damaged many crops in the area.

PHOTO: STR/AFP/GETTY IMAGES

North Korea
Young pupils in Sinuiju perform a dance routine for a group of Chinese tourists. The border town—separated from Dandong, China, by the Yalu River—has long been open to its neighbors. It began admitting some Western tourists in 2013.

PHOTO: WANG ZHAO, AFP/GETTY IMAGES.

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ACTOR PORTRAYAL

Indication and Limitations of Use

Trulicity is a once-weekly injectable prescription medicine to improve blood sugar (glucose) in adults with type 2 diabetes mellitus. It should be used along with diet and exercise. Trulicity is not recommended as the first medication to treat diabetes. It has not been studied in people who have had inflammation of the pancreas (pancreatitis). Trulicity should not be used by people with a history of severe gastrointestinal (GI) disease, people with type 1 diabetes, or people with diabetic ketoacidosis. It is not a substitute for insulin. It has not been studied with long-acting insulin or in children under 18 years of age.

Important Safety Information

Tell your healthcare provider if you get a lump or swelling in your neck, have hoarseness, trouble swallowing, or shortness of breath while taking Trulicity. These may be symptoms of thyroid cancer. In studies with rats or mice, Trulicity and medicines that work like Trulicity caused thyroid tumors, including thyroid cancer. It is not known if Trulicity will cause thyroid tumors or a type of thyroid cancer called medullary thyroid carcinoma (MTC) in people. Do not take Trulicity if you or any of your family members have ever had MTC or if you have Multiple Endocrine Neoplasia syndrome type 2 (MEN 2).

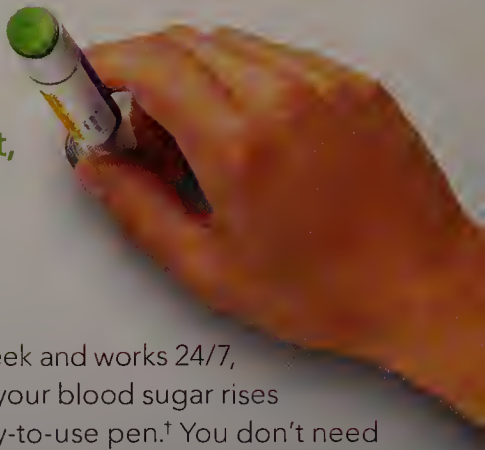
Do not take Trulicity if you have had an allergic reaction to dulaglutide or any of the other ingredients in Trulicity.

Trulicity may cause serious side effects, including:

- **Inflammation of your pancreas (pancreatitis).** If you have pain in your stomach area (abdomen) that is severe and will not go away, stop taking Trulicity and call your healthcare provider right away. The pain may happen with or without vomiting. It may be felt going from your abdomen through to your back.
- **Low blood sugar (hypoglycemia).** If you are using another medicine that can cause low blood sugar (such as insulin or a sulfonylurea) while taking Trulicity, your risk for getting low blood sugar (hypoglycemia) may be higher. Signs and symptoms of low blood sugar may include dizziness, blurred vision, anxiety, irritability, mood changes, sweating, slurred speech, hunger, confusion or drowsiness, shakiness, weakness, headache, fast heartbeat, or feeling jittery. Talk to your healthcare provider about low blood sugar and how to manage it.
- **Serious allergic reactions.** Stop taking Trulicity and get medical help right away if you have symptoms of a serious allergic reaction, such as itching, rash, or difficulty breathing.

Find out if you're eligible to pay as little as $25 for each of your first 26 prescriptions at **Trulicity.com**

Click to Activate Your Within.



Jerry uses what's inside him to reach his goals. For his art, he uses his passion. For his diabetes, he helps his body release its own insulin.

Ask your doctor about once-weekly, non-insulin Trulicity®.

- It helps activate your body to do what it's supposed to do—release its own insulin
- It can help improve A1C and blood sugar numbers
- You may lose a little weight*

*Trulicity is not a weight loss drug. In studies, people who lost weight lost 2-6 lbs on average.

- It's taken once a week and works 24/7, responding when your blood sugar rises
- It comes in an easy-to-use pen.† You don't need to see or handle a needle

†In a study, 94% of people said it was easy to use.

- **Kidney problems (kidney failure).** In people who have kidney problems, diarrhea, nausea, and vomiting may cause a loss of fluids (dehydration). This may cause kidney problems to get worse.
- **Severe stomach problems.** Trulicity may cause stomach problems, which could be severe.

Tell your healthcare provider if you:

- have or have had problems with your pancreas, kidneys, or liver.
- have severe problems with your stomach, such as slowed emptying of your stomach (gastroparesis) or problems with digesting food.
- have any other medical conditions.
- are pregnant or plan to become pregnant, or if you become pregnant while taking Trulicity. It is not known if Trulicity will harm your unborn baby.
- are breastfeeding or plan to breastfeed. It is not known if Trulicity passes into your breast milk. You should not use Trulicity while breastfeeding without first talking to your healthcare provider.
- are taking other medicines including prescription and over-the-counter medicines, vitamins, and herbal supplements. Trulicity may affect the way some medicines work and some medicines may affect the way Trulicity works.
- are taking other medicines to treat diabetes, including insulin or sulfonylureas.

The most common side effects with Trulicity may include: nausea, diarrhea, vomiting, decreased appetite, and indigestion. Talk to your healthcare provider about any side effect that bothers you or does not go away. These are not all the possible side effects of Trulicity. Call your doctor for medical advice about side effects.

You are encouraged to report side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

Please see next page for additional information about Trulicity, including Boxed Warning regarding possible thyroid tumors including thyroid cancer.

Please see Instructions for Use included with the pen.

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Trulicity is available by prescription only.

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0.75 mg/0.5 mL, 1.5 mg/0.5 mL

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Information for Patients about Trulicity (dulaglutide):

This is a brief summary of important information about Trulicity (Trū-li-si-tee). Please read the Medication Guide that comes with Trulicity before you start taking it and each time you get a refill because there may be new information. This information is not meant to take the place of talking with your healthcare provider or pharmacist.

What is Trulicity?

Trulicity is a once-weekly, injectable prescription medicine that may improve blood sugar (glucose) in adults with type 2 diabetes mellitus, and should be used along with diet and exercise.

- It is not recommended as the first choice of medicine for treating diabetes.
- It is not known if it can be used in people who have had pancreatitis.
- It is not a substitute for insulin and is not for use in people with type 1 diabetes or people with diabetic ketoacidosis.
- It is not recommended for use in people with severe stomach or intestinal problems.
- It is not known if it can be used with long-acting insulin or if it is safe and effective for use in children under 18 years of age.

What is the most important information I should know about Trulicity?

Trulicity may cause serious side effects including possible thyroid tumors, including cancer. Tell your healthcare provider if you get a lump or swelling in your neck, hoarseness, trouble swallowing, or shortness of breath. These may be symptoms of thyroid cancer. In studies with rats or mice, Trulicity and medicines that work like Trulicity caused thyroid tumors, including thyroid cancer. It is not known if TRULICITY will cause thyroid tumors or a type of thyroid cancer called medullary thyroid carcinoma (MTC) in people.

Who should not use Trulicity?

Do not use Trulicity if:

- you or any of your family have ever had a type of thyroid cancer called medullary thyroid carcinoma (MTC) or if you have an endocrine system condition called Multiple Endocrine Neoplasia syndrome type 2 (MEN 2).
- you are allergic to dulaglutide or any of the ingredients in Trulicity.

What are the possible side effects of Trulicity?

Trulicity may cause serious side effects, including:

- **Possible thyroid tumors, including cancer. See "What is the most important information I should know about Trulicity?"**
- **inflammation of the pancreas (pancreatitis).** Stop using Trulicity and call your healthcare provider right away if you have severe pain in your stomach area (abdomen) that will not go away, with or without vomiting. You may feel the pain from your abdomen to your back.
- **low blood sugar (hypoglycemia).** Your risk for getting low blood sugar may be higher if you use Trulicity with another medicine that can cause low blood sugar such as sulfonylurea or insulin.

Signs and symptoms of low blood sugar may include: dizziness or light-headedness; blurred vision; anxiety, irritability, or mood changes; sweating; slurred speech; hunger; confusion or drowsiness; shakiness; weakness; headache; fast heartbeat; feeling jittery.

- **serious allergic reactions.** Stop using Trulicity and get medical help right away, if you have any symptoms of a serious allergic reaction including itching, rash, or difficulty breathing.
- **kidney problems (kidney failure).** In people who have kidney problems, diarrhea, nausea, and vomiting may cause a loss of fluids (dehydration) which may cause kidney problems to get worse.
- **severe stomach problems.** Other medicines like Trulicity may cause severe stomach problems. It is not known if Trulicity causes or worsens stomach problems.

The most common side effects of Trulicity may include nausea, diarrhea, vomiting, decreased appetite, indigestion.

Talk to your healthcare provider about any side effect that bothers you or does not go away. These are not all the side effects of Trulicity.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

Before using Trulicity tell your healthcare provider if you:

- have had problems with your pancreas, kidneys, or liver.
- have severe problems with your stomach, such as slowed emptying of your stomach (gastroparesis) or problems digesting food.
- have any other medical conditions.
- are pregnant or plan to become pregnant, or if you become pregnant while taking Trulicity. It is not known if Trulicity will harm your unborn baby.
- are breastfeeding or plan to breastfeed. It is not known if Trulicity passes into your breast milk. You should not use Trulicity while breastfeeding without first talking to your healthcare provider.
- **are taking other medicines**—including prescription and over-the-counter medicines, vitamins, and herbal supplements. Trulicity may affect the way some medicines work and some medicines may affect the way Trulicity works.
- are taking other medicines to treat your diabetes including insulin or sulfonylureas.

Before using Trulicity, talk to your healthcare provider about low blood sugar and how to manage it.

How should I use Trulicity?

- Read the **Instructions for Use** that comes with Trulicity.
- Use Trulicity exactly as your healthcare provider tells you to.
- Your healthcare provider should show you how to use Trulicity before you use it for the first time.
- Trulicity is injected under the skin (subcutaneously) of your stomach (abdomen), thigh, or upper arm. **Do not** inject Trulicity into a muscle (intramuscularly) or vein (intravenously).
- **Use Trulicity 1 time each week on the same day each week at any time of the day.**
- You may change the day of the week as long as your last dose was given **3** or more days before.
- If you miss a dose of Trulicity, take the missed dose as soon as possible, if there are at least 3 days (72 hours) until your next scheduled dose. If there are less than 3 days remaining, skip the missed dose and take your next dose on the regularly scheduled day. **Do not** take **2** doses of Trulicity within **3** days of each other.
- Trulicity may be taken with or without food.
- **Do not** mix Trulicity and insulin together in the same injection.
- You may give an injection of Trulicity and insulin in the same body area (such as your stomach), but not right next to each other.
- Change (rotate) your injection site with each weekly injection. **Do not** use the same site for each injection.

Do not share your Trulicity pen, syringe, or needles with another person. You may give another person an infection or get an infection from them.

Your dose of Trulicity and other diabetes medicines may need to change because of:

- change in level of physical activity or exercise, weight gain or loss, increased stress, illness, change in diet, or because of other medicines you take.

For more information go to www.Trulicity.com or call 1-800-LillyRx (1-800-545-5979).

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The Pool

Assignment We asked the Your Shot community to visit a pool and use photography to explore above the water's surface, or below it.

EDITOR'S NOTE

'So many photos nailed the essence and magic of pool time—diving, floating, antics above and below the water, moments of spontaneity, and some creatively artful scenes.'

Sherry L. Brukbacher, *photo editor*

Tekla Szőcs
London, England

Szőcs, a photographer, had asked a friend to model for her at an abandoned pool in Budapest. The friend brought her young niece along. "We were playing around, jumping in puddles," Szőcs says. The girl stopped at one point to look down at the empty pool.

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EXPLORE

Wild Things

Birdcalls

Parrot communication goes well beyond "Polly wants a cracker." The colorful birds—whose family includes parakeets, like those on this page—actually speak in dialects.

Biologist Timothy Wright and his team at New Mexico State University used sonograms to compare vocalizations of Amazon parrots living in Costa Rica. They discovered that all birds used a specific call to maintain contact with others in their flock, but the acoustic structure of that call varies by region. And when one bird heard the local dialect of another, it modified its own vocalizations to match the new tune. They found comparable patterns with small flocks of parakeets in the lab.

Humans and parrots learn to vocalize similarly: Both listen and then repeat back what was heard. Relatively few animals develop communication this way. The trait may help explain why parrots are such popular pets. In the wild they form strong pair bonds and social systems; in captivity they may try to re-create that connectedness by mimicking the humans around them.

"Learning how to sound like others is very important to parrots," says Wright. "When you sound like another, that means you are a member of their group." —*Scott Burkhard*

NAT GEO WILD

Experience the Amazon's unfolding drama at the height of flood season on *Amazon Underworld*, premiering Sunday, February 21, on Nat Geo WILD.

PHOTO: CLAIRE ROSEN

Power of Positive Speaking

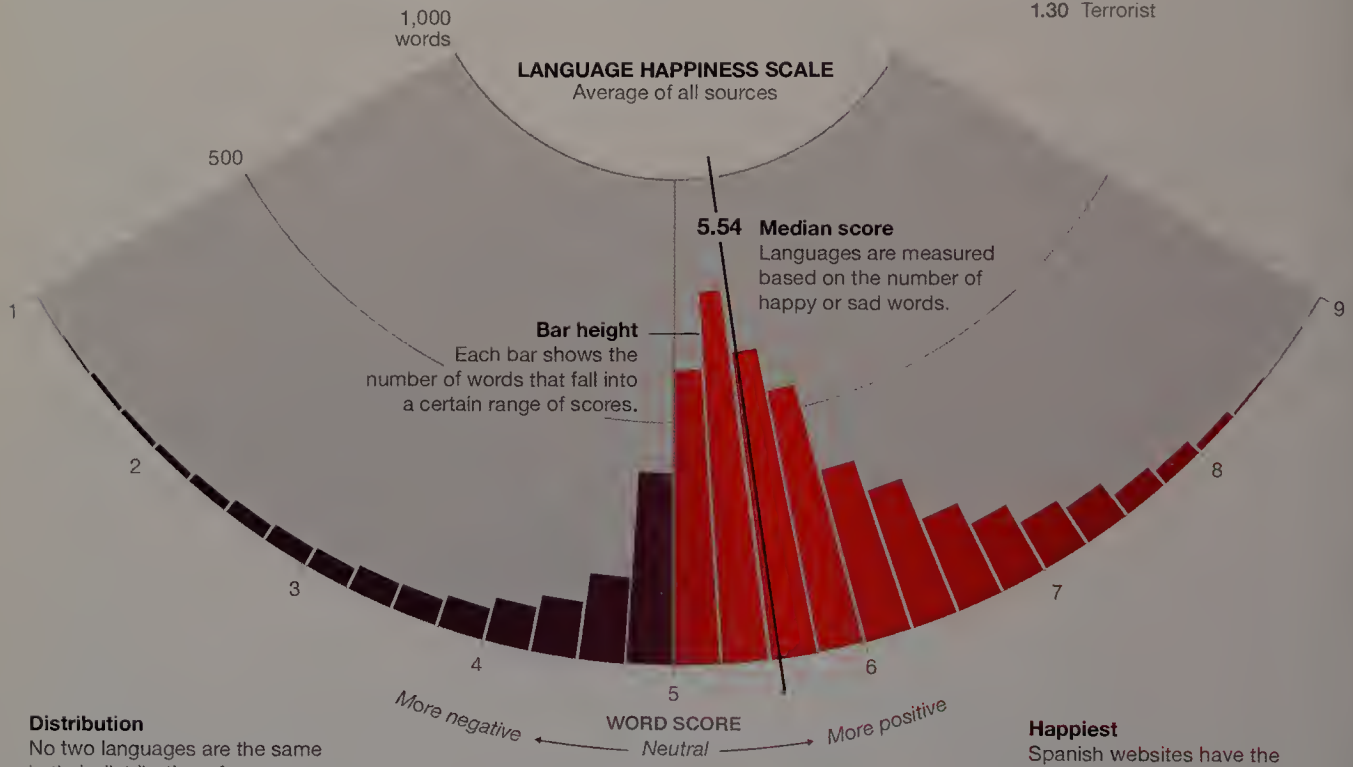
Optimists, you're not alone: Turns out most people look on the bright side of life—or at least talk about it. A recent study by University of Vermont data scientist Peter Dodds and colleagues found a universal positive bias in languages.

Dodds and his team gathered billions of words from ten languages and 24 types of sources—books, news, social media—then identified the 5,000 words most frequently used in each tongue. When people were asked to rate words on a nine-point "happy-to-sad" scale, results were more positive than negative. And when words were translated across languages, people rated words similarly.

University of Pennsylvania linguist Mark Liberman says Dodds's big-data study supports previous anecdotal findings that humans tend to focus on the positive. Will emotional gauges join economic indexes as a measure of well-being? Dodds hopes so: "Without a metric for happiness, you can't improve it." —*Jeremy Berlin*

Universal happiness
Native speakers in ten languages ascribed a positivity score—from one to nine—to each of their 5,000 most commonly used words. The results show that while some languages are "happier" than others, they all have a positive bias.

Sample word scores
8.50 Laughter
6.66 Advice
4.84 Secret
1.98 Headache
1.30 Terrorist



Distribution
No two languages are the same in their distribution of scores. Chinese books, for example, have many words clustered in a relatively neutral range.

Happiest
Spanish websites have the most positive score overall. But Dodds says the big takeaway is that "we all tend to favor a positive set of words."

MATTHEW TWOMBLY, NGM STAFF. SOURCES: PETER SHERIDAN DODDS AND CHRIS M. DANFORTH, UNIVERSITY OF VERMONT; BRIAN F. TIVNAN, MITRE CORPORATION

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Bumpy calcite blankets part of an early Neanderthal's skull and other bones.

A Cave Man's Tale

Members of a caving club made a startling discovery in 1993 while exploring one of the many limestone chambers near Altamura, Italy: a skeleton partly covered with calcite knobs. At the time experts concluded this was an adult male Neanderthal who had likely fallen into the cave and starved to death. Repeated splashes of mineral-rich water created the knobs, called cave popcorn.

A new study has determined that the calcite covering began forming about 130,000 years ago, so the victim must have lived—and died—prior to that. DNA extracted from a shoulder bone confirmed the original identification. "This is the oldest Neanderthal whose DNA has been analyzed," says David Caramelli of the University of Florence. More sophisticated DNA research in the future may reveal how this extinct cousin of early humans is related to others of his kind and where he sits on the larger evolutionary tree. *—A. R. Williams*

STATUE WITH A SECRET

A marble dolphin with a fish in its mouth turned up unexpectedly at a site in the Negev. Archaeologists from the Israel Antiquities Authority found the 16-inch-tall statue embedded in the floor of a seventh-century building. They believe it was created earlier and recycled as a paving stone. It may once have been part of a statue of Poseidon, the Greek god of the sea, or a local form of Aphrodite, the goddess born in sea-foam. But it also may have had a hidden message. "A dolphin eating a fish symbolizes the persecution of early Christians," says Alexander Fraiberg. "That means the source of the statue may be a Byzantine church." *—ARW*

PHOTOS: SOPRINTENDENZA ARCHEOLOGIA DELLA PUGLIA (TOP); CLARA AMIT, ISRAEL ANTIQUITIES AUTHORITY

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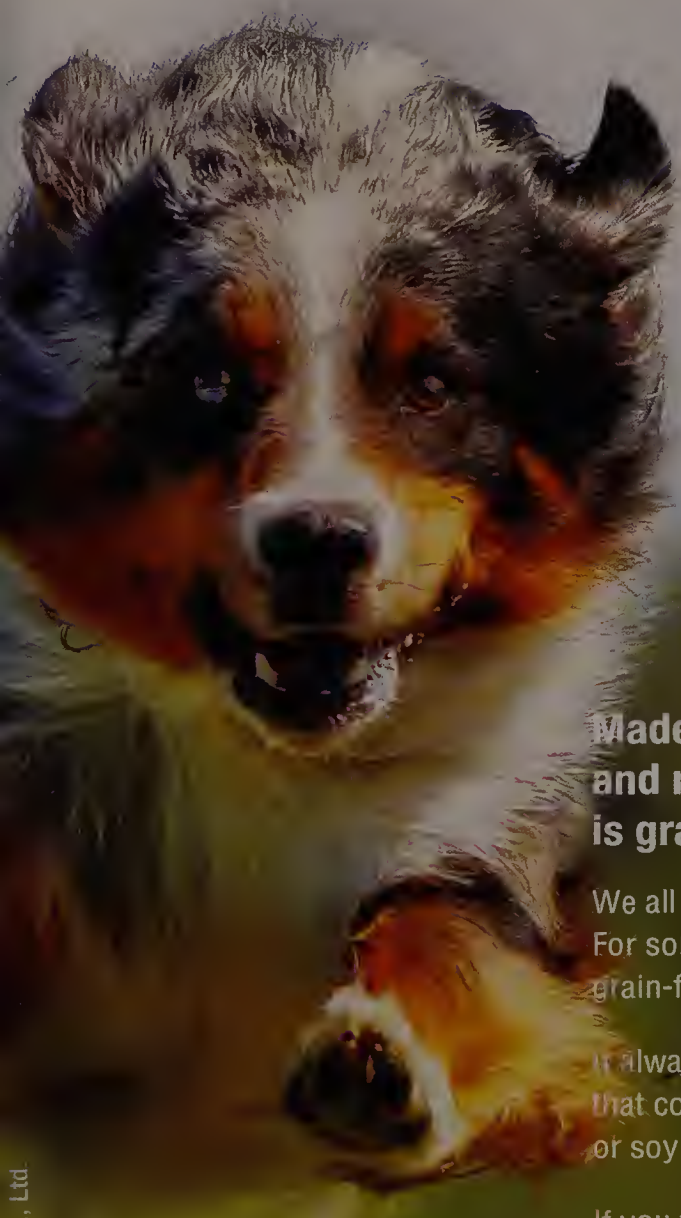

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We all want our dogs and cats to look and feel their best. For some of our furry friends, that means being on a grain-free diet, which is why we created BLUE Freedom.

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If you think your dog or cat can do better on a grain-free diet, you can't do better than BLUE Freedom.

SetYourPetsFree.com

Love them like family. Feed them like family.®

Available for dogs and cats.

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Crop Diversity

Farmers once cultivated a wider array of genetically diverse crop varieties, but modern industrialized agriculture has focused mainly on a commercially successful few. Now a rush is on to save the old varieties—which could hold genetic keys to developing crops that can adapt to climate change.

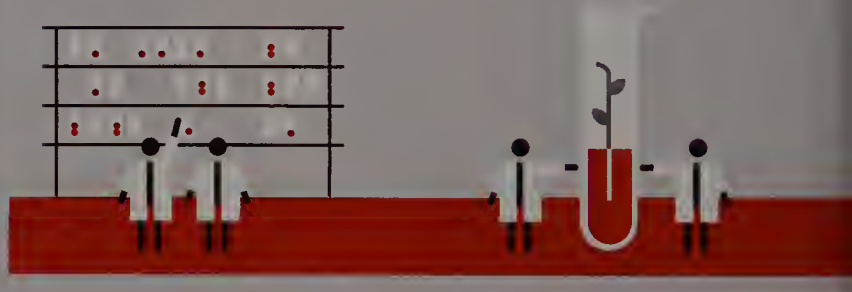
"No country is self-sufficient with its plant genetic resources," says Francisco Lopez, of the secretariat of the International Treaty on Plant Genetic Resources for Food and Agriculture. The group oversees the exchange of seeds and other plant materials that are stored in the world's 1,750 gene banks. *—Kelsey Nowakowski*

THE POTATO CHALLENGE

Potatoes in southwestern China had long been plagued by disease, so scientists began searching for blight-resistant varieties that could be grown in tropical highlands. By the mid-1990s researchers at Yunnan Normal University in China and the International Potato Center (CIP) in Peru had created a new resistant spud using Indian and Filipino potatoes.

POTATO GENE BANK

RESISTANT PARENT 1

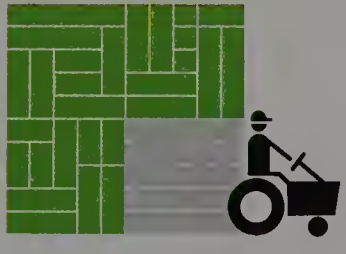


A Potatoes originated in Peru and Bolivia. CIP conserves some 4,300 varieties and shares genetic resources with breeders around the world.

B For the female parent, researchers from CIP and the Philippines found an Indian potato that was resistant to viruses and harmful late blight.

LOSING VARIETIES

75 PERCENT OF CROP DIVERSITY HAS BEEN LOST SINCE 1900.



WE NOW DEPEND ON JUST A FEW CROPS,

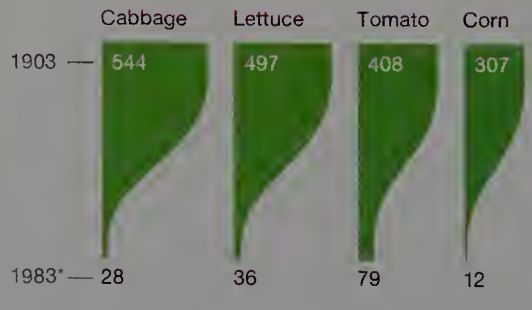
30,000 edible plants are available globally.

7,000 are cultivated or collected for food.

30 staple crops feed most of the world.

AND THE VARIETY IS SHRINKING.

The number of commercially available seed varieties in the U.S. dropped significantly in the 20th century, as large-scale agriculture became more uniform.



*Latest data available

"COOPERATION-88," THE MIGHTY TUBER

Released in 1996, the high-yielding and widely grown variety Cooperation-88 is now a staple of China's potato chip industry.

960,000

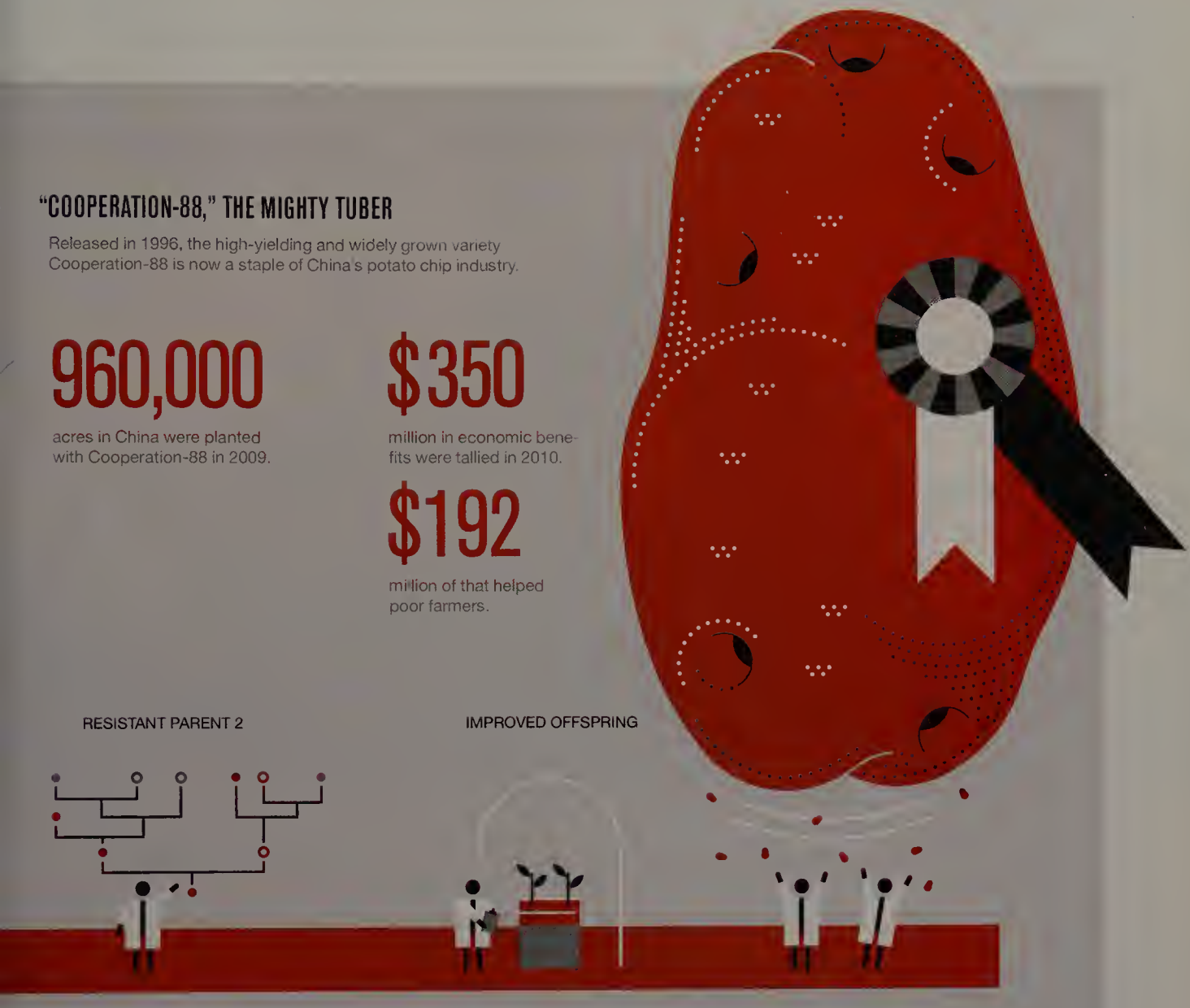
acres in China were planted with Cooperation-88 in 2009.

$350

million in economic benefits were tallied in 2010.

$192

million of that helped poor farmers.



C The male parent came from the pollen of late-blight-resistant breeds developed by scientists at CIP and in a graduate study project in the Philippines.

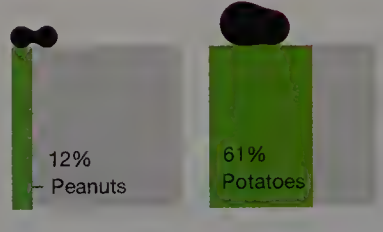
D The resulting potato seeds were sent to China for evaluation. After five years of trials and selection, the new variety, named Cooperation-88, was declared resistant to viruses and late blight, suitable for southwestern China's growing conditions — and, crucially, tasty to eat.

WHAT'S AT STAKE

Less diversity means more vulnerability, since researchers have fewer genetic options as they try to develop varieties that are resistant to pests, floods, and drought brought on by climate change.

20-40%

Portion of global yield lost each year to plant pests and diseases



Portion of crop varieties that could be lost in 50 years due to climate change

GRAPHIC: ÁLVARO VALIÑO. SOURCES: INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE; RURAL ADVANCEMENT FOUNDATION INTERNATIONAL; FAO; INTERNATIONAL POTATO CENTER; LI AND OTHERS, *AMERICAN JOURNAL OF POTATO RESEARCH*, 2011

For people with a higher risk of stroke due to
Atrial Fibrillation (AFib) not caused by a heart valve problem

I won't accept going for less than my best.

ELIQUIS® (apixaban) is a prescription medicine used to reduce the risk of stroke and blood clots in peo who have atrial fibrillation, a type of irregular heartbeat, not caused by a heart valve problem.

IMPORTANT SAFETY INFORMATION:

- **Do not stop taking ELIQUIS for atrial fibrillation without talking to the doctor who prescribed it for you. Stopping ELIQUIS increases your risk of having a stroke.** ELIQUIS may need to be stopped, prior to surgery or a medical or dental procedure. Your doctor will tell you when you should stop taking ELIQUIS and when you may start taking it again. If you have to stop taking ELIQUIS, your doctor may prescribe another medicine to help prevent a blood clot from forming.
- **ELIQUIS can cause bleeding, which can be serious,** and rarely may lead to death.
- **You may have a higher risk of bleeding if you take ELIQUIS and** take other medicines that increase your risk of bleeding, such as aspirin, NSAIDs, warfarin (COUMADIN®), heparin, SSRIs or SNRIs, and other blood thinners. **Tell your doctor about all medicines, vitamins and supplements you take.**

While taking ELIQUIS, you may bruise more eas and it may take longer than usual for any bleedi to stop.

- Get medical help right away if you have any these signs or symptoms of bleeding:
  - unexpected bleeding, or bleeding that lasts a long time, such as unusual bleeding from the gums; nosebleeds that happen often, or menstrual or vaginal bleeding that is heavier than normal
  - bleeding that is severe or you cannot control
  - red, pink, or brown urine; red or black sto (looks like tar)
  - coughing up or vomiting blood or vomit that loo like coffee grounds
  - unexpected pain, swelling, or joint pain; headache feeling dizzy or weak
- **ELIQUIS is not for patients with artificial heart valv**

Now I'm going for something better than warfarin. ELIQUIS.

Reduced the risk of stroke better than warfarin.

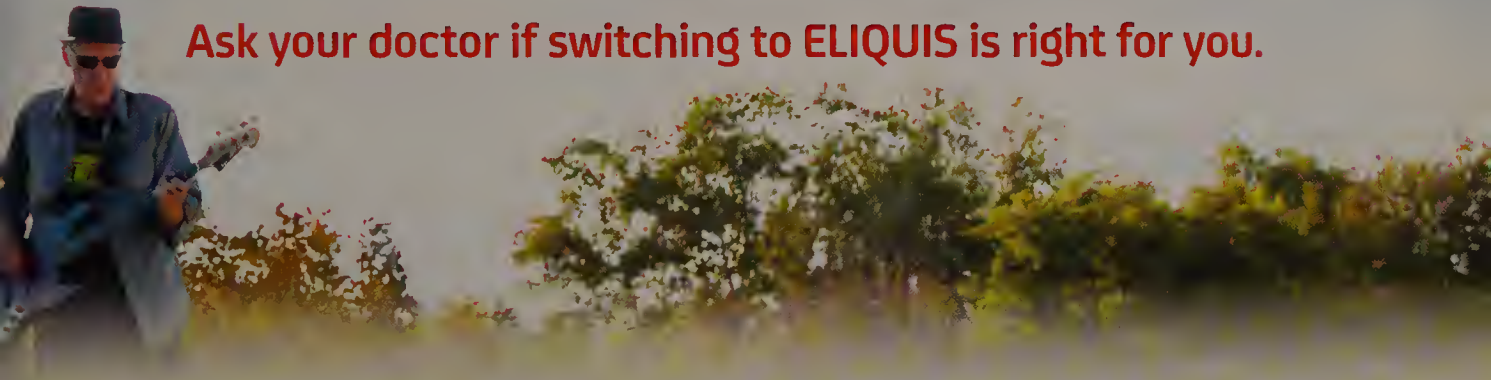
ELIQUIS® (apixaban)

Had significantly less major bleeding than warfarin.

No routine blood testing.

ELIQUIS and other blood thinners increase the risk of bleeding which can be serious, and rarely may lead to death.

Ask your doctor if switching to ELIQUIS is right for you.



Spinal or epidural blood clots (hematoma). People who take ELIQUIS, and have medicine injected into their spinal and epidural area, or have a spinal puncture have a risk of forming a blood clot that can cause long-term or permanent loss of the ability to move (paralysis). This risk is higher if, an epidural catheter is placed in your back to give you certain medicine, you take NSAIDs or blood thinners, you have a history of difficult or repeated epidural or spinal punctures. Tell your doctor right away if you have tingling, numbness, or muscle weakness, especially in your legs and feet.

Before you take ELIQUIS, tell your doctor if you have: kidney or liver problems, any other medical condition, or ever had bleeding problems. Tell your doctor if you are pregnant or breastfeeding, or plan to become pregnant or breastfeed.

Do not take ELIQUIS if you currently have certain types of abnormal bleeding or have had a serious allergic reaction to ELIQUIS.

A reaction to ELIQUIS can cause hives, rash, itching, and possibly trouble breathing. Get medical help right away if you have sudden chest pain or chest tightness, have sudden swelling of your face or tongue, have trouble breathing, wheezing, or feeling dizzy or faint.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Please see additional Important Product Information on the adjacent page.

Individual results may vary.

Learn about savings and offers.

Visit ELIQUIS.COM or call 1-855-ELIQUIS

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432US1S03794-02-01 2/16

Eliquis®
(apixaban) tablets

IMPORTANT FACTS about ELIQUIS® (apixaban) tablets

℞ ONLY

The information below does not take the place of talking with your healthcare professional. Only your healthcare professional knows the specifics of your condition and how ELIQUIS may fit into your overall therapy. Talk to your healthcare professional if you have any questions about ELIQUIS (pronounced ELL eh kwiss).

What is the most important information I should know about ELIQUIS (apixaban)?

For people taking ELIQUIS for atrial fibrillation: Do not stop taking ELIQUIS without talking to the doctor who prescribed it for you. Stopping ELIQUIS increases your risk of having a stroke. ELIQUIS may need to be stopped, prior to surgery or a medical or dental procedure. Your doctor will tell you when you should stop taking ELIQUIS and when you may start taking it again. If you have to stop taking ELIQUIS, your doctor may prescribe another medicine to help prevent a blood clot from forming.

ELIQUIS can cause bleeding which can be serious, and rarely may lead to death. This is because ELIQUIS is a blood thinner medicine that reduces blood clotting.

You may have a higher risk of bleeding if you take ELIQUIS and take other medicines that increase your risk of bleeding, such as aspirin, nonsteroidal anti-inflammatory drugs (called NSAIDs), warfarin (COUMADIN®), heparin, selective serotonin reuptake inhibitors (SSRIs) or serotonin norepinephrine reuptake inhibitors (SNRIs), and other medicines to help prevent or treat blood clots.

Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.

While taking ELIQUIS:

- you may bruise more easily
- it may take longer than usual for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding when taking ELIQUIS:

- unexpected bleeding, or bleeding that lasts a long time, such as:
  - unusual bleeding from the gums
  - nosebleeds that happen often
  - menstrual bleeding or vaginal bleeding that is heavier than normal
- bleeding that is severe or you cannot control
- red, pink, or brown urine
- red or black stools (looks like tar)
- cough up blood or blood clots
- vomit blood or your vomit looks like coffee grounds
- unexpected pain, swelling, or joint pain
- headaches, feeling dizzy or weak

ELIQUIS (apixaban) is not for patients with artificial heart valves.

Spinal or epidural blood clots (hematoma). People who take a blood thinner medicine (anticoagulant) like ELIQUIS, and have medicine injected into their spinal and epidural area, or have a spinal puncture have a risk of forming a blood clot that can cause long-term or permanent loss of the ability to move (paralysis). Your risk of developing a spinal or epidural blood clot is higher if:

- a thin tube called an epidural catheter is placed in your back to give you certain medicine
- you take NSAIDs or a medicine to prevent blood from clotting
- you have a history of difficult or repeated epidural or spinal punctures
- you have a history of problems with your spine or have had surgery on your spine

If you take ELIQUIS and receive spinal anesthesia or have a spinal puncture, your doctor should watch you closely for symptoms of spinal or epidural blood clots or bleeding. Tell your doctor right away if you have tingling, numbness, or muscle weakness, especially in your legs and feet.

What is ELIQUIS?

ELIQUIS is a prescription medicine used to:

- reduce the risk of stroke and blood clots in people who have atrial fibrillation.
- reduce the risk of forming a blood clot in the legs and lungs of people who have just had hip or knee replacement surgery.

(Continued on adjacent page)

- treat blood clots in the veins of your legs (deep vein thrombosis) or lungs (pulmonary embolism), and reduce the risk of them occurring again.

It is not known if ELIQUIS is safe and effective in children.

Who should not take ELIQUIS (apixaban)?

Do not take ELIQUIS if you:

- currently have certain types of abnormal bleeding
- have had a serious allergic reaction to ELIQUIS. Ask your doctor if you are not sure

What should I tell my doctor before taking ELIQUIS?

Before you take ELIQUIS, tell your doctor if you:

- have kidney or liver problems
- have any other medical condition
- have ever had bleeding problems
- are pregnant or plan to become pregnant. It is not known if ELIQUIS will harm your unborn baby
- are breastfeeding or plan to breastfeed. It is not known if ELIQUIS passes into your breast milk. You and your doctor should decide if you will take ELIQUIS or breastfeed. You should not do both

Tell all of your doctors and dentists that you are taking ELIQUIS. They should talk to the doctor who prescribed ELIQUIS for you, before you have **any** surgery, medical or dental procedure. **Tell your doctor about all the medicines you take, including** prescription and over-the-counter medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way ELIQUIS works. Certain medicines may increase your risk of bleeding or stroke when taken with ELIQUIS.

How should I take ELIQUIS?

Take ELIQUIS exactly as prescribed by your doctor. Take ELIQUIS twice every day with or without food, and do not change your dose or stop taking it unless your doctor tells you to. If you miss a dose of ELIQUIS, take it as soon as you remember, and do not take more than one dose at the same time.

Do not run out of ELIQUIS (apixaban). Refill your prescription before you run out. When leaving the hospital following hip or knee replacement, be sure that you will have ELIQUIS available to avoid missing any doses. **If you are taking ELIQUIS for atrial fibrillation, stopping ELIQUIS may increase your risk of having a stroke.**

What are the possible side effects of ELIQUIS?

- See **"What is the most important information I should know about ELIQUIS?"**
- ELIQUIS can cause a skin rash or severe allergic reaction. Call your doctor or get medical help right away if you have any of the following symptoms:
  - chest pain or tightness
  - swelling of your face or tongue
  - trouble breathing or wheezing
  - feeling dizzy or faint

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of ELIQUIS. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

This is a brief summary of the most important information about ELIQUIS. For more information, talk with your doctor or pharmacist, call 1-855-ELIQUIS (1-855-354-7847), or go to www.ELIQUIS.com.

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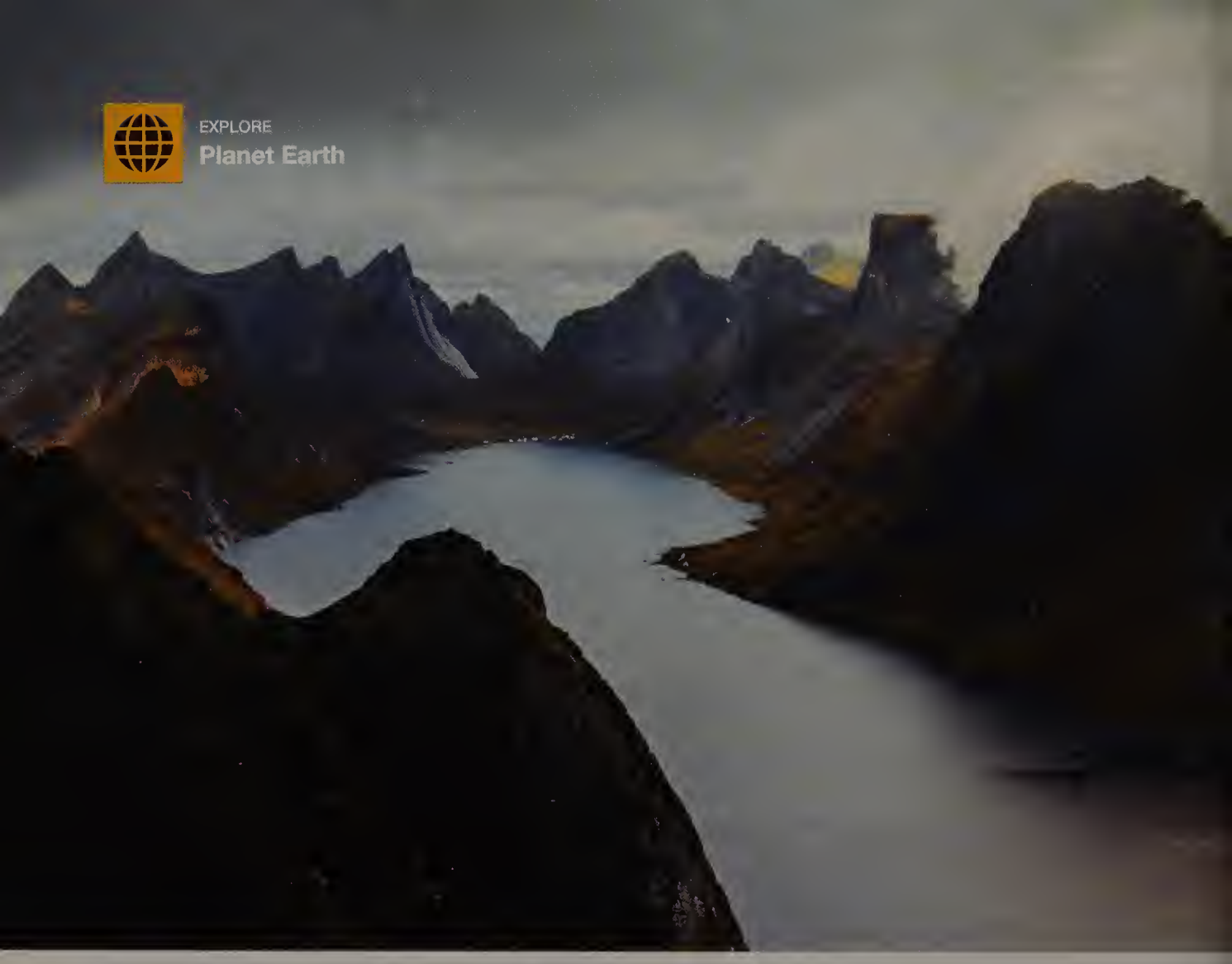
June 2015
432US1S01088-10-01



Stored in the Fjord

Scientists have long known that oceans store carbon from the organic matter that washes into them. Instead of being released into the atmosphere as harmful carbon dioxide, carbon can be locked up underwater for millions of years.

New research shows that fjords, like the one above in Norway, are even more adept than oceans at holding on to carbon: Per square mile, the glacier-carved waterways hoard a hundred times the ocean's average. They're fed by swift mountain rivers, and their depth and sinewy shape transport and store organic matter relatively efficiently, taking in an overall 11 percent of the carbon buried in marine areas annually.

But humans shouldn't exploit them as dumps for carbon. The fjords' power rests in staying pristine, says chemical oceanographer Richard W. Smith of Global Aquatic Research. "I don't feel like we can do it better than nature's already doing it. We'd get in there and muck things up." *—Nina Strochlic*

RATING SNOWFLAKES FOR SAFETY

Every snowflake may be unique, but some types cause more trouble—avalanches, treacherous roads—than others. Knowing which kind is coming down on which road could help highway crews respond more swiftly to storms.

A high-speed camera developed by Tim Garrett and his colleagues at the University of Utah captures detailed images of snow crystals. "It's around the freezing point that you really want to know what's falling," says Garrett. "Our instrument is able to diagnose sleet, snow, or rain." No worries about the flake at right: It hits the ground as light, fluffy snow. *—Rachel Hartigan Shea*

PHOTOS: ERLEND HAARBERG (TOP); TIM GARRETT, NATIONAL SCIENCE FOUNDATION

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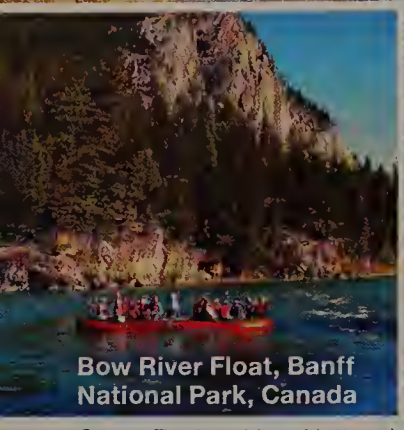

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LEGAL NOTICE

If you were called on a cellular telephone about a debt by or on behalf of Midland Credit Management, Inc., you may be entitled to receive a payment or debt forgiveness.

WHAT IS THIS CASE ABOUT?

A Settlement has been reached in a class action lawsuit *In re: Midland Credit Management, Inc. Telephone Consumer Protection Act Litigation*, United States District Court for the Southern District of California Case No. 11-MD-2286 MMA (MDD) (the "Lawsuit"). Plaintiffs allege that Midland Funding, LLC, Midland Credit Management, Inc. ("MCM"), and Encore Capital Group, Inc. (collectively, "Defendants") violated the Telephone Consumer Protection Act ("TCPA"), by calling cell phone numbers using an automatic telephone dialing system or an artificial or prerecorded voice between November 2, 2006 and August 31, 2014, inclusive (the "Class Period"), without prior express consent. The Court did not decide in favor of Plaintiffs or Defendants and Defendants deny any violation or liability. To settle the case, Defendants will provide a Settlement Fund totaling $15,000,000 composed of a $13,000,000 Debt Forgiveness Component and a $2,000,000 Cash Component. If you have an existing account with Defendants with a balance owed, and you have an approved claim, you will receive a credit against any amounts you owe in an amount based on a pro rata division of the Debt Forgiveness Component, which will depend on the number of those claims submitted. If you do not have an existing account with Defendants, and you have an approved claim, you will receive a cash payment based upon a pro rata division of the Cash Component, which will depend on the number of those claims submitted. Defendants will also pay separate from that Settlement Fund the costs of notice and claims administration, estimated to be about $3,350,000 and pay attorneys' fees and costs up to $2,400,000, subject to Court approval.

HOW DO I KNOW IF I WAS CALLED ON MY CELLPHONE DURING THE CLASS PERIOD?

If you have not received a postcard notice advising you of this settlement, you still may have been called by Defendants during the Class Period. The Claims Administrator has a list of cellphone numbers called. If you believe you were called by Defendants on any cellphone you had during the Class Period, you may determine that during the Claims Process described below. You must provide to the Claims Administrator your cellphone number(s) on which you may have been called and the Claims Administrator can compare your number(s) to those on the list of cellphone numbers called by Defendants during the Class Period. If your number was called, you are a Class Member and entitled to file a claim, but no more than one claim, regardless of how many numbers were called.

WHAT ARE MY OPTIONS?

You can submit a claim as described below. Or if you do nothing, you remain a Class Member, and if the Court approves the settlement, you will be legally bound by its terms and will release your claims relating to calls placed by, or on behalf of, Defendants.

If you want to exclude yourself from this settlement, you must send a written request specifically stating that you request exclusion from the settlement to In re: Midland TCPA Claims Administrator, PO Box 30198, College Station, TX 77842-3198 postmarked no later than **April 22, 2016**.

If you remain a Class Member, you may object to the settlement by writing to Class Counsel and Defense Counsel, and file such objections with the Court, all no later than **April 22, 2016**.

Full details on how to object or exclude yourself can be found at www.MidlandTCPAsettlement.com.

SETTLEMENT HEARING

The Court will hold a hearing on August 26, 2016 at 9:00 a.m., to consider whether to approve the settlement as fair and reasonable, award a $2,500 incentive payment to each of the three class representatives, award attorneys' fees and litigation costs in an amount not to exceed $2,400,000.

You or your lawyer may ask to appear and speak at your own expense. A more detailed Notice and a explanation of the claims process are available at www.MidlandTCPAsettlement.com. The website also explains the Settlement terms in more detail. You may write to In re: Midland TCPA Claims Administrator, PO Box 30198, College Station, TX 77842-3198 to request the more detailed Notice and a paper Claim Form for mailing in a claim.

TO RECEIVE A PAYMENT YOU MUST SUBMIT A CLAIM. YOU MAY COMPLETE AND SUBMIT A CLAIM BY CALLING 1-888-557-3460, OR YOU MAY SUBMIT A CLAIM ONLINE BY VISITING WWW.MIDLANDTCPASETTLEMENT.COM. YOU MAY ALSO PRINT A COPY OF THE CLAIM FORM AVAILABLE AT WWW.MIDLANDTCPASETTLEMENT.COM, COMPLETE IT, AND MAIL IT TO: IN RE: MIDLAND TCPA CLAIMS ADMINISTRATOR, PO BOX 30198, COLLEGE STATION, TX 77842-3198. ALL CLAIMS MUST BE SUBMITTED OR POSTMARKED BY APRIL 12, 2016.

www.MidlandTCPAsettlement.com

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Tanzania

The Maasai: changed, for better or worse, by cell phones

TIMOTHY BAIRD *Geography researcher*

The Maasai people of Kenya and Tanzania live a semi-nomadic, pastoral life, seeking out areas of fresh pasture and building enclosures to protect their livestock. For cultural anthropologists who wonder how off-the-grid people are being changed by a world of screens, Internet, and fast communication, the Maasai are an ideal test case.

Tim Baird is observing the transformation in progress. "Phones are a profound new tool for them," says Baird, a Virginia Tech geography professor who has studied Maasai cell phone culture under a National Geographic grant. Instant connectivity where none existed before has changed the type of people a Maasai person can reach, he says, and the type of information shared. That includes weather data for farmers, market prices for livestock, and—even though tradition sometimes dictates arranged marriages between young girls and older men—ways for girls to flirt with boys their own age. After all, Baird notes, even some older-model mobile phones can access Facebook.

Phones can store money, which has introduced Maasai to mobile banking (and its untidy companion, fraud). Business transactions are faster and more efficient when they don't have to be conducted face-to-face. When Baird convened groups of Maasai to discuss phone culture, men consistently mentioned two things they photograph: women and cows.

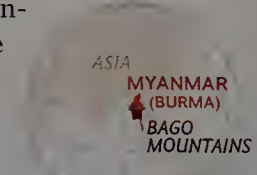
Baird has heard the criticism that 21st-century technology is diluting the historically rustic culture. But that critique rarely comes from Maasai themselves, who, according to Baird's findings, generally see a mobile phone as a tool that's empowering rather than intrusive. "They're not jumping on Epicurious to see how to make a soufflé; they're using phones in ways that are relevant to their lives," he says. "Phones help them solve their problems." *—Daniel Stone*

Even simple cell phone models call for accessories, which in East African Maasai villages are often handmade.

Myanmar (Burma)

Journeys with beloved elephants

MOLLY FERRILL *Young Explorer*



Ferrill reports: My first insight into the Burmese people's respect for elephants came from Ma Lwin, a shopkeeper in a farming village in the western Bago Mountains. It was

PHOTO: TIMOTHY BAIRD, NATIONAL GEOGRAPHIC CREATIVE. NGM MAPS

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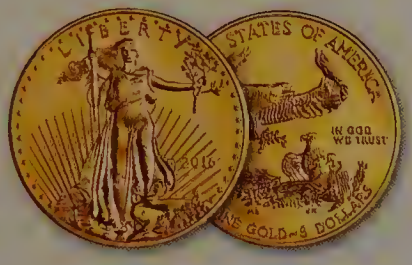

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late afternoon when I arrived, covered in sand after a long motorcycle ride across a barren landscape. Inside Ma Lwin's bamboo hut, she offered me hot tea and scolded me for traveling through dangerous elephant territory.

Back when the mountains were covered in forest, she told me, elephants and people had lived in harmony. But now that their habitat was being cut and burned down for rubber plantations, the elephants were forced to roam long distances searching for food, sometimes knocking down villagers' fragile bamboo huts and threatening farmers in the fields. Even so, the farmers told me they loved the elephants, calling them *boe daw gyi,* or respected elders.

That was the beginning of months spent journeying through forests and villages to document the connection between people and elephants in Myanmar. During my time there, children in timber camps played alongside elephants used for logging; a caravan escorted a sacred white elephant to the capital to be welcomed by the vice president—and one day park rangers led me to an elephant giving birth. As I watched, the calf took its first breath.

Development often gives us the excuse to discard old traditions and destroy the environment. In many countries this has allowed elephant populations to dwindle. But observing so many people's high regard for elephants in Myanmar gives me hope that, in this time of transition, they won't be left behind.

National Geographic, the anti-trafficking group Freeland, and camera maker Sigma funded Molly Ferrill's studies of elephants, including this mother and baby.

Africa to North America

Fresh eland? Finger-licking good

BILL SCHINDLER AND CAT BIGNEY
Survival experts

On the open savanna of central Tanzania, Bill Schindler and Cat Bigney find a freshly killed eland. Famished and dehydrated, the two dig into the carcass, licking blood from their fingers. The predator that made the kill—probably a lion—could return at any moment. So Schindler and Bigney rip off a leg and climb up a tree.

Schindler is a professor of anthropology, and Bigney is a primitive-skills instructor. Together they're running in *The Great Human Race,* a National Geographic Channel survival series that airs Mondays from February to April. The two are traveling 35,000 miles in the footsteps of early humans, using only the tools people had at each evolutionary stage. In Tanzania that means living like *Homo habilis,* who survived 2.4 million years ago in part by scavenging other animals' kills. By the last episode the pair will have complex hunting tools at their disposal.

"All of this is our shared history as humans," says Schindler. "No matter who you are, you had an ancestor who successfully made or used stone tools and who successfully mastered fire." Filming the voyage from East Africa to North America spanned eight months. The same distance took early humans an estimated 1.9 million years. *—Nina Strochlic*

PHOTO: MOLLY FERRILL. NGM MAPS

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Digging Dirt, and Each Other

"Sex-mad," roared the headline in the U.K.'s *Daily Mail.* The news report quoted Sheffield, England, homeowners' complaints that their "neighbours from hell" were having "noisy late-night passionate encounters outside."

Get a room, *Meles meles!* Then again, the Eurasian badger's homemaking may be as disruptive as its lovemaking: It can ruin lawns and undermine buildings as it digs setts, the chamber-and-tunnel systems it calls home.

Who knows whether badgers' favorite pastime is digging or breeding. Clans move tons of earth to create labyrinthine setts; some incorporate tunnels that their fore-badgers dug centuries ago. They pile up leafy bedding (which they regularly change) in chambers used for indoor breeding. During sex, females may yelp, males may emit a cross between a whinny and a purr—and the sound carries. When badgers dug a love nest under a Derbyshire church, "there was much concern over the pungent odours and strange noises that emanated during evensong," according to the 1996 book *Badgers.*

Flexible as to where they have sex, badgers are also biologically blessed as to when. A female can maintain embryos "in a sort of suspended animation" and delay their implantation in her uterus for months, says wildlife biologist Dez Delahay of the University of Exeter. As a result, badgers can breed all year and still time their babies' birth to a season when conditions most favor their survival. Only a few mammal species have that reproductive advantage, so *Meles meles* really does have something to purr about. *—Patricia Edmonds*

HABITAT/RANGE
Forests and grasslands, Europe to East Asia

CONSERVATION STATUS
Least concern

OTHER FACTS
In England, killing or harming badgers or damaging their setts is an offense punishable by up to six months in prison and $7,500 in fines.

Badgers place leafy bedding—and change it regularly—in their breeding chambers.

PHOTO: MARK TAYLOR, NATURE PICTURE LIBRARY

ROYAL ROSE
ORGANIC
ROYAL ROSE

waste not

About a third of the planet's food goes to waste.

In California's Salinas Valley growers annually trash thousands of tons of fresh greens that lack sufficient shelf life for a cross-country journey.

Vat not

That's enough to feed two billion people.

At a Paris feast chefs simmer cosmetically challenged veggies—gleaned or donated—into a curry for 6,100 anti-waste enthusiasts.

By Elizabeth Royte
Photographs by Brian Finke

Tristram Stuart has 24 hours to produce a restaurant meal for 50 people—to plan a menu, gather food, then welcome guests to a venue in a city not his own. Complicating what sounds like a reality-show contest is a singular rule: Nearly all the ingredients must be sourced from farms and vendors intending to throw them out.

After racing back to New York City from a New Jersey farm where he gleaned 75 pounds of crookneck squash deemed by the farmers too crooked to sell, Stuart bolts from a car creeping through traffic and darts into a Greenwich Village bakery. Tall and blond, with a posh English accent, he launches into his ten-second spiel: "I run an organization that campaigns against food waste, and I'm pulling together a feast tomorrow made with food that won't be sold or donated to charity. Do you have any bread that we could use?" The bakery doesn't, but the clerk hands him two broken chocolate-chip cookies as consolation.

Stuart flings himself into the car. His next stop: the Union Square farmers market, where he spies a chef wrapping fish in squares of brioche dough, then trimming them into half circles. "Can I have your corners?" Stuart asks, with a meant-to-be-charming smile. The chef, uncharmed, declines. He's going to make use of this dough himself. Undaunted, Stuart sails on through the market, delivering his pitch and eventually procuring discarded beet greens, wheatgrass, and apples.

Eighteen hours later scores of chefs, food-recovery experts, and activists talk shop over

This story is part of National Geographic's Future of Food initiative, a special five-year project that seeks to show how what we eat makes us who we are.

Near Apartadó, Colombia, activist Tristram Stuart examines bananas too short, long, or curved for the European market. Locals consume some rejected bananas, but growers in the region annually dump millions of tons of edible fruit.

chef Celia Lam's squash tempura, turnip and tofu dumplings, and spiralized zucchini noodles. Stuart himself had cooked very little, but he had, without a single formal meeting, ensorcelled a half dozen people to devise a menu, gather ingredients, and then prep, cook, serve, and clean up a meal for little more than the chance to be associated with one of the most compelling figures in the international fight against food waste.

ACROSS CULTURES, food waste goes against the moral grain. After all, nearly 800 million people worldwide suffer from hunger. But according to the Food and Agriculture Organization of the United Nations, we squander enough food—globally, 2.9 trillion pounds a year—to feed every one of them more than twice over. Where's all that food—about a third of the planet's production—going? In developing nations much is lost postharvest for lack of adequate storage facilities,

good roads, and refrigeration. In comparison, developed nations waste more food farther down the supply chain, when retailers order, serve, or display too much and when consumers ignore leftovers in the back of the fridge or toss perishables before they've expired.

Wasting food takes an environmental toll as well. Producing food that no one eats—whether sausages or snickerdoodles—also squanders the water, fertilizer, pesticides, seeds, fuel, and land needed to grow it. The quantities aren't trivial. Globally a year's production of uneaten food guzzles as much water as the entire annual flow of the Volga, Europe's most voluminous river. Growing the 133 billion pounds of food that retailers and consumers discard in the United States annually slurps the equivalent of more than 70 times the amount of oil lost in the Gulf of Mexico's *Deepwater Horizon* disaster, according to *American Wasteland* author Jonathan Bloom. These staggering numbers don't even include the losses from farms, fishing vessels, and slaughterhouses. If food waste were a country, it would be the third largest producer of greenhouse gases in the world, after China and the U.S. On a planet of finite resources, with the expectation of at least two billion more residents by 2050, this profligacy, Stuart argues in his book *Waste: Uncovering the Global Food Scandal,* is obscene.

Others have been making similar arguments for years, but reducing food waste has become a matter of international urgency. Some U.S. schools, where children dump up to 40 percent of their lunches into the trash, are setting up sharing tables, letting students serve themselves portions they know they'll eat, allotting more time for lunch, and scheduling it after recess—all proven methods of boosting consumption. Countless businesses, such as grocery stores,

Thirty percent of the mandarin crop in Huaral, Peru, won't meet exacting export standards. Most of the rejects will be eaten locally. Globally 46 percent of fruits and vegetables never make it from farm to fork.

Lost and Tossed: Fruit and Vegetables

Every year some 2.9 trillion pounds of food—about a third of all that the world produces—never get consumed. Along the supply chain fruits and vegetables are lost or wasted at higher rates than other foods. Easily bruised and vulnerable to temperature swings en route from farm to table, they're also usually the first to get tossed at home.

LOST
Produce abandoned or discarded during harvesting, shipping, or processing
FRUIT AND VEGETABLE SUPPLY CHAIN*
20%
Lost during picking and sorting
3%
Lost during storage and shipping
2%
Lost during juice production, canning, or baking
*AUSTRALIA, CANADA, NEW ZEALAND, AND U.S. DATA ONLY

restaurants, and cafeterias, have stepped forward to combat waste by quantifying how much edible food isn't consumed, optimizing their purchasing, shrinking portion sizes, and beefing up efforts to move excess to charities. Stuart himself has made a specialty of investigating conditions farther up the supply chain, where supermarket standards and ordering practices lead to massive, but mostly hidden, dumps of edible food.

FIFTY MILES NORTH OF LIMA, Peru, in the farming town of Huaral, Stuart sips a glass of freshly squeezed satsuma juice with Luis Garibaldi, whose Fundo Maria Luisa is the largest grower of mandarins in the country. Pitched forward in his seat under a poolside pergola, Stuart asks: How much do you export? How much is rejected? For what reason? And what happens to those discards? Seventy percent of his crop, Garibaldi says, is exported to the European Union and North America. But 30 percent won't be the right size, color, or sweetness, or it might have blemishes, scars, scratches, sunburn, fungus, or spiders. To local markets most of these rejects go, netting Garibaldi just one-third the price of the exports.

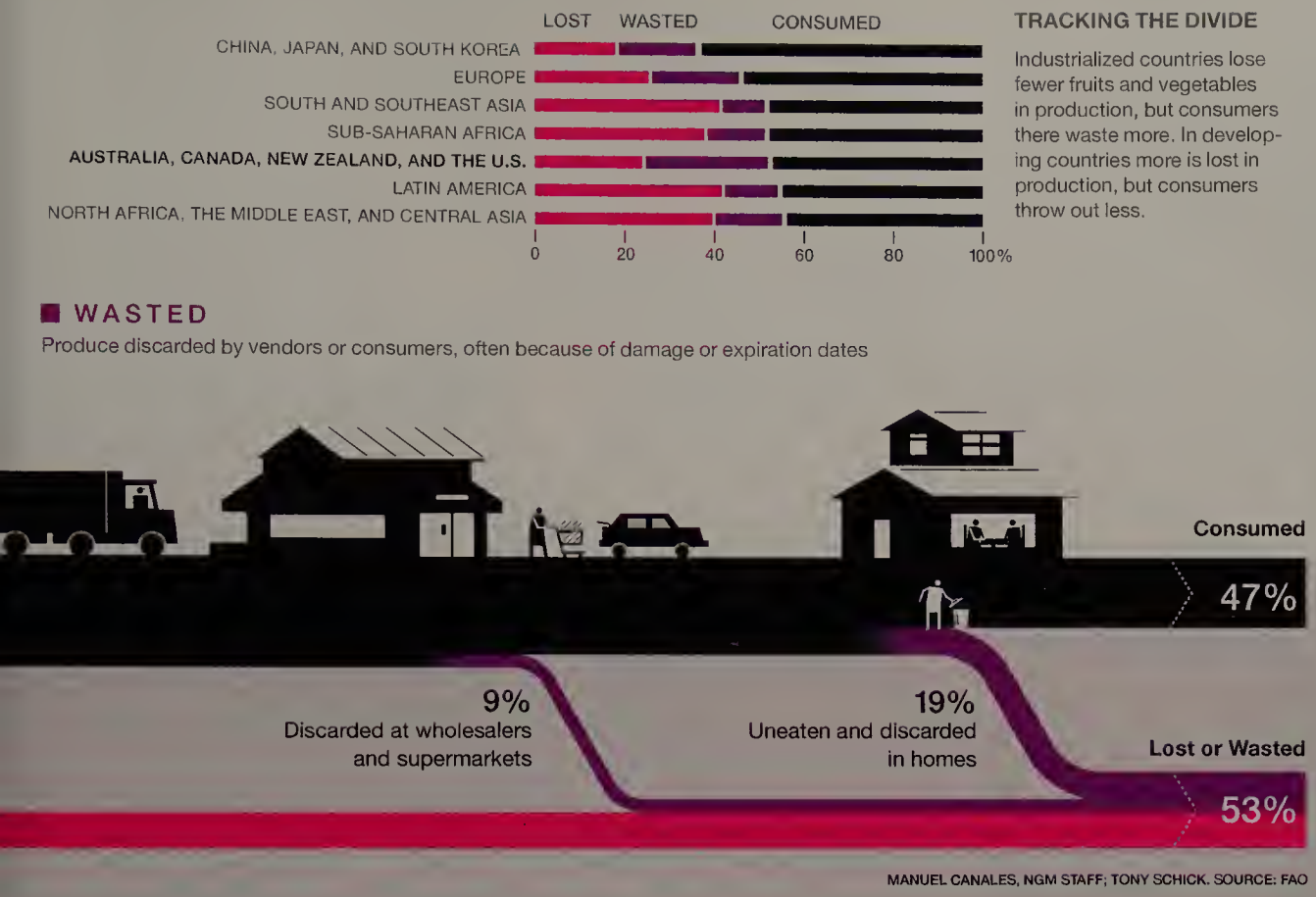
Stuart works through a ladder of queries that lead to a general thesis: Supermarkets' cosmetic standards are crazily exacting—until supply shrinks, at which point they crumble like a chocolate lattice.

"So grocers purchase this slightly imperfect fruit, and consumers still buy it?" Stuart asks.

"Yes," Garibaldi says, nodding.

In the fragrant orchard, which lies in a valley under the parched crenellations of the Cordilleran foothills, Stuart plucks a mandarin unfit for any market but stops short of eating it. "I don't mind maggots, actually, but that one was fermented," he says, choosing instead a fruit with two tiny brown spots. Fundo Maria Luisa, it turns out, generates relatively little waste, thanks to its U.K. representative, who examines shipments and negotiates with any buyers poised to reject fruit for specious reasons. Often, Garibaldi says, a supermarket's rejection of food for cosmetic reasons is merely a cover-up for its inaccurate forecasts or an unexpected drop in sales. Either way, the grower is expected to eat the loss.

We drive 200 miles south, past tall sand dunes and wind-eroded ridges. All is ocher and dust



MANUEL CANALES, NGM STAFF; TONY SCHICK. SOURCE: FAO

until we reach valleys suddenly verdant with irrigated farmland—a consequence of foreign investment, favorable trade agreements, cheap labor, a warm climate, and a once bountiful aquifer. In the Ica Region, Stuart interviews a farmer who annually abandons in his fields millions of stalks of asparagus too thin or too curved or with bud tips slightly too open to export. Next a producer tells him that he dumps more than a thousand tons of infinitesimally imperfect Minneola tangelos and a hundred tons of grapefruit a year into a sandpit behind his packhouse.

Grade standards—industry driven and voluntary—were devised long ago to provide growers and buyers with a common language for evaluating produce and mediating disputes. They also can help reduce food waste. If growers can sort their asparagus or tangelos into established grades, they stand a better chance of finding markets for their "seconds." Supermarkets have always been free to set their own standards, of course, but in recent years upscale grocers have started running their produce departments like beauty pageants, responding to customers, they say, who expect only platonically ideal produce: apples round and shiny, asparagus straight and tightly budded.

"It's all about quality and appearance," says Rick Stein, vice president of fresh foods at the Food Marketing Institute. "And only the best appearance will capture share of the consumer's wallet." Some of the produce that doesn't capture share will be donated to food banks or chopped up and used in a supermarket's prepared meals or salad bar, but most of U.S. grocers' excess food is neither donated nor recycled. Stuart applauds some U.S. and EU supermarkets' recent campaigns to sell "ugly" produce at a discount, but he prefers a systemic fix. "It would be far better to simply relax the standards," he says, surveying a sea of abandoned Peruvian citrus for which no secondary market—ugly or otherwise—exists.

> Saving trashed food has become a matter of international urgency.

FOR SEVEN DAYS Stuart traipses around farms and packhouses, runs through his questions,

Gleaning for Good

IN THE PICARDY REGION OF FRANCE a volunteer helps glean 1,100 pounds of potatoes too small to harvest mechanically. The potatoes will join carrots, eggplants, and other gleaned and donated vegetables at Paris's Place de la République. There volunteers allied with Stuart's group Feedback will chop this bounty into a meal for 6,100 diners. Feedback has helped organize more than 30 of these public feasts around the world to raise awareness of food waste and inspire local solutions.

Salvaging Scraps

FOR MORE THAN 50 YEARS RC Farms has been collecting Las Vegas kitchen waste and plate scrapings, like these zucchini sticks and fries from the coffee shop at Jerry's Nugget Casino. Hauled a short distance to Bob and Janet Combs's third-generation farm, the food scraps will be sterilized and fed to 2,500 pigs, replacing more than 800 tons of swine feed a year. Portions in U.S. restaurants have increased significantly in recent decades, contributing to obesity and food waste.

gathers data, and samples rejects. Between visits he folds himself like a fruit bat into the backseat of a crowded car and types. Tap, tap. He's working out logistics for his next research trip, then accepting a drinks invitation from the general manager of the Food Bank of Peru. Tap, tap. An appointment with a food rescuer who just flew up from Santiago, Chile. Everywhere he goes, it seems, people want to tell Stuart an egregious story about food waste.

Sleep-deprived, unshaven, and sometimes hungover—what's the point of being in a new country if you can't sample what's locally fermented?—Stuart remains focused. In fume-choked traffic he arranges to meet with a Peruvian congressman trying to overturn tax laws that incentivize dumping excess food over donating it. As we careen down a serpentine road, he taps out revisions to a proposed food-waste-reduction bill in the U.K. Parliament and a letter in support of expanding the authority of the U.K.'s Groceries Code Adjudicator. Next he floats to colleagues the idea of a Lima "disco soup"—a communal meal of rejected food, similar to the feast in New York City—to be held in four days for 50 to 100 people.

The possibility spurs a series of calls to his newest friends. "You are totally awesome," he says, hyperenunciating. "Do you think we might

HEINZ
TOMATO
KETCHUP

be able to... It's outrageous of me to ask but..." What's the goal of the disco soup, besides rescuing food? Raising awareness and building community. This squishy stuff works. While gleaning, dicing, and dining, chefs from Lima to London have connected with charities hungry for their excess; California entrepreneurs have hatched schemes to rescue wonky-looking fruit from burial; civil society groups have fomented plans for a Kenyan food-rescue network; a Belgian brewer has been emboldened to convert stale bread into salable beer.

A disco soup in Lima seems harebrained, given that Stuart is five hours from the city, has a looming appointment at a Colombian banana plantation, controls neither a dining room nor a kitchen, and has no budget and no food. But history suggests he will probably succeed.

> Stuart takes every opportunity to eat low on the hog—congealed chicken blood, guinea pig, tripe.

STUART, NOW 38, was born in London, the last of three boys. He lived in the city part-time but at 14 took up full-time residence with his father in rural East Sussex, where the family kept a large house in Ashdown Forest, the model for Winnie-the-Pooh's Hundred Acre Wood. Just across the valley lay what had been his grandparents' estate, a sprawling property with enough farm staff during World War II to field a cricket team against the local village. Stuart's father, Simon, had grown up there, and his stories about the farm's bounty bewitched his youngest son.

Simon Stuart was a talented teacher of English and an outstanding naturalist. "We could never learn everything he knew," Tristram recalls. "So my brothers and I split it up. One did birds, another did dragonflies, and I did mushrooms." (Dining on a $22 pizza topped with "wild" mushrooms the night before his New York City feast, Stuart lights into the waiter. "Your menu is s---. I'm a forager. I know what wild mushrooms look like, and these are from a shop.")

Living miles from the nearest town but psychologically close to his grandparents' self-sufficient farm defined Stuart. His father tended a large vegetable garden, and Stuart added pigs and chickens to the mix. In exchange for manure, Simon gave Tristram his vegetable trimmings. "So I had eggs and meat, and I'd go out with my ferrets to catch rabbits and shoot deer," Stuart says. The larder was almost complete. Stuart had begun selling pork and eggs to the parents of his schoolmates, but he quickly realized that buying animal feed would bankrupt him. He started a swill route: collecting misfit potatoes and stale cakes from local shops and his school kitchen. He bred his sow, Gudrun, and he learned how much edible food the community daily discarded.

Stuart's environmental consciousness was expanding. At 12, he'd written a paper likening the burning of fossil fuels to smoking cigarettes—both were self-destructive and addictive. After spending part of a year on a French cattle farm, he entered the University of Cambridge, where he studied English literature and experienced a cruel uprooting from his agro-ecological heaven. The school food was produced "with no attention to sustainable criteria," he says. In response he joined other campus activists who were dining on food they'd liberated from supermarket Dumpsters. He also drank cider pressed from strangers' apples, shared the roasted brains, rolled spleens, and crisped ears of Gudrun's many offspring, and—after learning they were tasty—slurped snails from friends' gardens.

It's not surprising to learn that Stuart once dabbled in theater. "I quite liked it," he says, though it eventually threatened to "get in the way of the really important work of saving the planet." He was sufficiently self-aware to realize that privileged students plucking unopened tubs of ricotta from rubbish bins had great rhetorical potential. At that time, he says, neither supermarkets nor

An employee at Las Vegas's Aria Resort and Casino sorts the edible from the inedible. Feeding the scraps to nonruminant animals, such as pigs, recycles their nutrients and eliminates some of the methane that food would generate in a landfill.

government agencies had any overt policies on food waste. That was about to change.

By 2002 Stuart's bin diving had attracted enough attention for him to help produce a food-waste documentary for a BBC politics show, and activists around the world were reaching out to him to partner on food rescues. (He was living then in London.) With enough data on where and precisely why food was lost throughout the food chain, he realized, he might actually be able to do something about it. Thus were sown the seeds of his book *Waste,* in which he investigated the causes and environmental toll of food waste around the globe.

Waste was critically acclaimed, but Stuart knew the data-heavy book wouldn't be read by millions, and he desperately wanted millions to support his cause. "Hence, Feeding the 5,000," he says, echoing Jesus' instruction in John 6:12 to "gather the pieces that are left over. Let nothing be wasted." Launched in 2009, Feeding the

5,000 would become Stuart's flagship event—a free public feast made entirely of orphaned food. These gatherings have now been replicated in more than 30 cities. Thousands partake of the meals, reams of ink and pixels follow, and public outcry is amplified. Soon Stuart was giving speeches around the world and sharply criticizing the food industry's most powerful actors, many of whom he put on the defensive with his polemics. Supermarkets, in turn, considered him "a pain in the ass," he says. "And I was."

From whence does Stuart's formidable self-confidence spring? One hardly knows where to begin. Stuart is ambitious, aggressive, and narcissistic. But he's also eloquent, amusing, and supremely knowledgeable on his central topic. "When he speaks, you want to join him," says Dana Gunders, a food-waste specialist with the Natural Resources Defense Council who authored the *Waste Free Kitchen Handbook*. "He's really good at not only kindling that passion in others but maintaining it, adding to the army of passionate people who want to do something about food waste."

STUART TAKES EVERY OPPORTUNITY to eat low on the hog—the better to keep what's uncoveted from rubbish bins and to model positive behavior. On his first morning in Peru he breakfasts on congealed chicken blood. "I've never had that before," he says, happily. At lunch he exults in guinea pig. On day two he orders beef tripe; on day three, tongue and a great deal of pisco. Such is his macho carnivorism that when Stuart tells me he's procured "fried balls" for a hasty airport lunch, I assume he's talking about testicles. They turn out to be relatives of the potato knish.

The protein seems to fortify Stuart for farm and packhouse conversations that quickly grow weedy with numbers. Kilos, tons, containers,

At RC Farms, just ten or so miles from the Las Vegas Strip, hogs convert surplus potatoes from a local food processor into protein that may eventually find its way onto our plates.

Mother's Maid
Cut
GREEN BEANS
GREEN BEANS
GREEN BEANS

Selling Surplus

STAGGERED TO LEARN THAT the U.S. wastes 30 to 40 percent of its food while one in seven people suffers from food insecurity, Doug Rauch, former president of Trader Joe's, opened a nonprofit supermarket in Dorchester, Massachusetts. Called Daily Table, the supermarket sells discounted fruits and vegetables that are about to be discarded because they're too close to peak freshness; it also sells inexpensive surplus goods and prepares healthy to-go meals. "Hunger and wasted food," Rauch says, "are two problems that can have one solution."

Eating Ugly

EVERY YEAR some six billion pounds of U.S. fruits and vegetables go unharvested or unsold, often for aesthetic reasons. Imperfect, a start-up based in Emeryville, California, buys outré-looking produce from farmers and delivers it, at low cost, to more than a thousand San Francisco Bay Area subscribers. U.S. and European retail chains also have had success selling odd-looking fruits and vegetables at discount. "We're redefining beauty, not taste," says Ron Clark, an Imperfect founder.

pallets, percentages rejected, recovered, left for dead. His stomach for such minutiae is large. "I want to be able to tell Europeans that their preference for a closed tip on their asparagus equals X million acres of land, X million gallons of water, and X million pounds of fertilizer wasted." He takes a breath. "I need to make a headline, to tell people in a concise way that their choices matter."

Indeed they do. With governments fretting over how to feed more than nine billion people by 2050, a dominant narrative calls for increasing global food production by 70 to 100 percent. But agriculture already represents one of the greatest threats to planetary health. It is responsible for 70 percent of the planet's freshwater withdrawals, 80 percent of the world's tropical and subtropical deforestation, and 30 to 35 percent of human-caused greenhouse gas emissions. As the population grows and emerging economies develop a taste for meat and dairy products, which require huge inputs of grain and other resources for relatively little caloric gain, this toll will worsen. But converting more wildlands to farm fields may not be necessary, some experts say. If we slash waste, change our diet to eat less meat and dairy, divert fewer food crops to biofuels, and boost yields

Reducing Waste: How You Can Help

Developed countries are responsible for most of the food left uneaten on grocery-store shelves, on restaurant plates, and in home refrigerators. Here are some tips to reduce your waste footprint.

AT A STORE

Make careful decisions about what and how much you buy at the grocery store.

- Shop at stores that offer misshapen food at a discount.
- Purchase prepared meals at the deli or salad bar, which allows supermarkets to make use of imperfect produce.
- Buy frozen foods, which suffer fewer losses from farm to shelf.
- Shop often. Start with a large trip and then make smaller follow-ups to buy a few days' worth of produce at a time.
- Buy fresh food at local farmers markets.

AT A RESTAURANT

Americans spend about as much at restaurants as they do at grocery stores.

- Skip the cafeteria tray. Diners who use trays waste 32 percent more than those who carry their plates in their hands.
- Take home leftovers.
- Share side dishes to keep portions under control.
- Ask the waiter to hold extras such as bread and butter you don't plan to eat.
- Encourage restaurants and caterers to donate leftovers.

MANUEL CANALES, NGM STAFF

on underperforming acres, we may be able to feed more than nine billion people a healthy diet without trashing more rain forests, plowing up more prairies, or wiping out more wetlands.

Stuart never loses sight of this big picture, but he knows that paradigm changes are incremental. And so he stands in the desert behind an Ica packinghouse, hammering away at Luis Torres, general manager of Shuman Produce Peru. Lacking a local market for what he cannot export, Torres annually dumps 3.5 million pounds of small or imperfectly spherical onions. But he's reluctant to blame buyers for this loss.

"If I complain, the supermarket will find a new farmer," he says, shrugging. "I am a practical person. I can do nothing to change the rules."

Standing with his feet spread and arms crossed, Stuart replies, "I can."

THREE YEARS AGO Stuart spent a week running around the Kenyan countryside, hunting down ingredients for a formal dinner in Nairobi where the United Nations Environment Programme (UNEP) would highlight the problem of food waste. A hundred miles from the capital, he met a farmer forced by European cosmetic standards to reject 40 tons a week of green beans, broccoli, sugar snap peas, and runner beans—enough food to serve 250,000 people. Within a year Stuart and a camera crew returned to Kenya and discovered that farmers were grading out nearly half of their harvest in fields and packhouses, with green bean farmers losing even more product by trimming both the tips and the tails of each surviving bean. Supermarkets also routinely canceled orders at the last minute without compensating the farmers. After Feedback publicized images of the rejected beans and accused major supermarket chains of transferring their costs to relatively powerless growers, U.K. grocers were ready to talk. They eventually agreed to bear the cost of order cancellations and to expand the length of their packaging, which allowed green beans to be trimmed at only one end. Not only would less food and fewer resources be wasted, but farmers might also be able to plant fewer acres.

Society Grant Tristram Stuart is a National Geographic emerging explorer; his fieldwork was funded in part by the National Geographic Society.

AT HOME

Small changes in the kitchen can reduce the amount of food your household throws out.

- Use FoodKeeper or other apps for food-expiration reminders.
- Switch to smaller dishes to control portions. The standard plate is 36 percent larger than it was 50 years ago.
- Eat leftovers on a regular night each week.
- Give uneaten food a second chance. Freeze or can extras. Blend bruised fruit into smoothies.
- Try not to waste water-intensive foods like meat.

IN YOUR COMMUNITY

Businesses, schools, nonprofits, and governments can all find ways to dump less food.

- Bring back home economics classes to teach cooking, canning, and storage basics.
- Get your school to join the USDA Food Waste Challenge.
- Ask your local government for a curbside food-scrap collection service like that provided in roughly 200 U.S. communities.
- Share the bounty of your home garden with your community through *ampleharvest.org*.

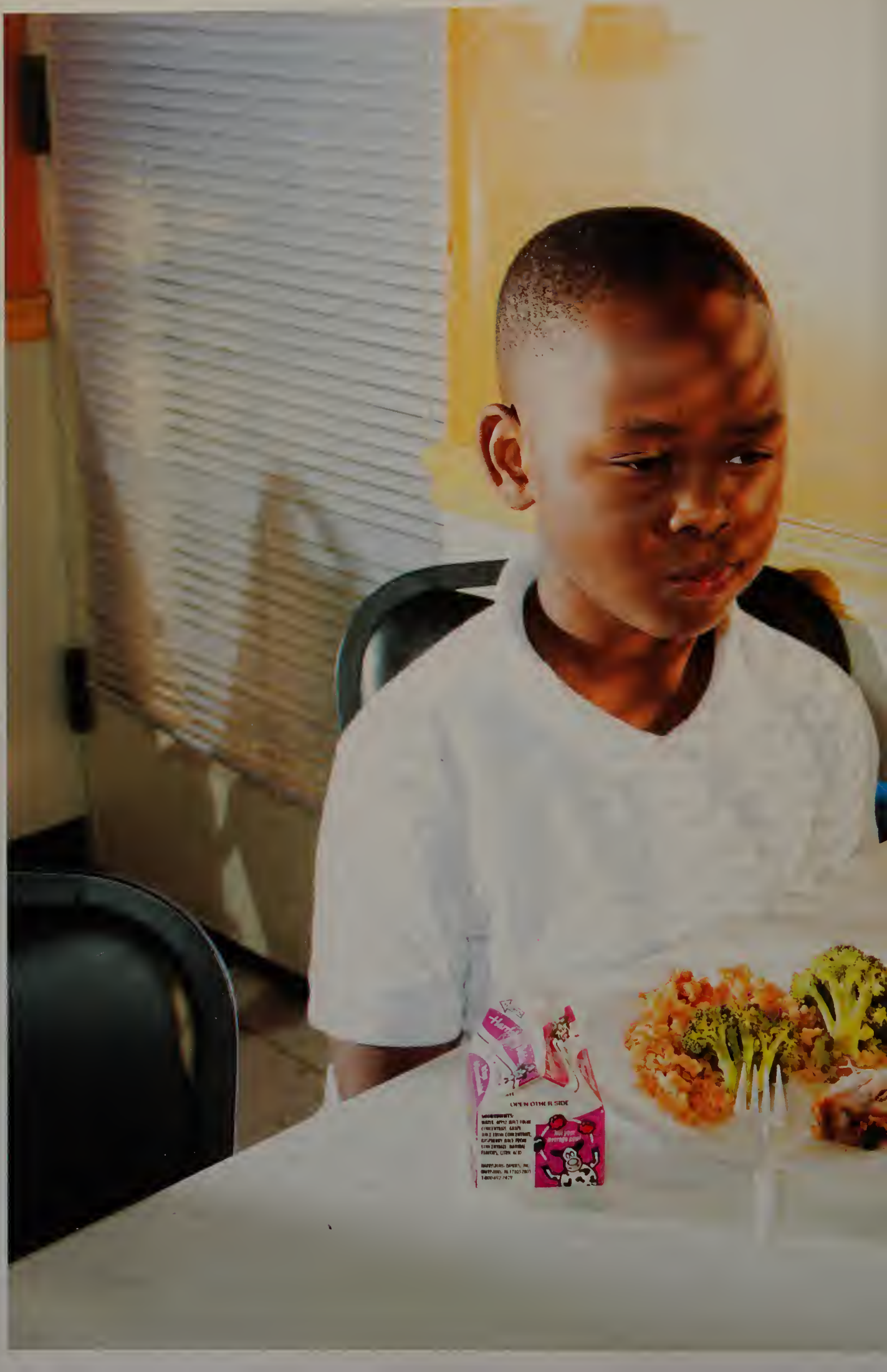
"Tristram identified a problem, and he did something about it," says Clementine O'Connor, a consultant on sustainable food to the UNEP. "He's been a lone voice defending farmers from unfair trading practices, identifying barriers, and catalyzing action, often in cases where supermarkets and governments were not aware of the problem."

Feedback's 2015 report on Kenyan green beans was just one achievement in a watershed year. By the end of 2015 the UN and the U.S. had pledged to halve food waste by 2030. The exact mechanisms of this ambitious goal haven't been spelled out. But already countries and companies are devising and adopting standardized metrics to quantify waste. If the target is met, enough food could be saved to feed at least one billion people.

> Two-legged carrots and eggplants chant, 'No more vegetable waste!'

ON AN OVERCAST Thursday afternoon in September, Stuart strides through a muddy field in northern France. He plunges his hands into a mound of soil and extracts several thin-skinned potatoes, which, being the size of thimbles and thumbs, had slipped through the mechanical harvester's grasp. For the next hour and a half he and a team of gleaners comb through the soil. The goal is to gather 1,100 pounds of spuds for Sunday's Feeding the 5,000 event, to be held in Paris's locus of civic activism, the stately Place de la République. The next day Stuart and another team of volunteers from partner organizations wash their enormous haul in a ramshackle squat in the 12th arrondissement. Standing shirtless in a cluttered room redolent of sweat and pot, with music blasting, Stuart scolds a woman for wasting time by scrubbing the potatoes twice. Feeling bullied, she blurts a two-word vulgarism. Stuart crows, "That's what everyone says to me!"

On Saturday it's time to chop. Gathering at rows of plastic tables in the square, hundreds of volunteers come and go over a period of four hours, dicing roughly 3,900 pounds of potatoes, eggplants, carrots, and red peppers—some


OPEN OTHER SIDE

Feeding a Need

AT THE BENNING PARK Community Center in Washington, D.C., third-grader Kevin Boyd eats an after-school dinner provided by DC Central Kitchen, a nonprofit that trains chefs and provides 11,000 meals a day in shelters, schools, and other locations. Almost half these meals come from food that would otherwise have gone to waste. At the center the students do their homework and learn how to make healthy meals, such as smoothies and homemade granola. "I always tell him, Don't say you don't like it until you try it," says Kevin's mother, Antoinette Boyd.

gleaned from farms, some donated by the Rungis wholesale market. Mostly veterans of mass production, the helpers shuttle produce from crates to giant plastic bowls and then to blue plastic bags. At 5 a.m. on Sunday the chef, Peter O'Grady, a Hare Krishna who runs a charity kitchen in London, tips those bags into chest-high metal tanks atop gas burners.

As midday approaches, the park grows crowded. Musicians perform onstage, and two-legged carrots and eggplants parade and chant, "No more vegetable waste!" Stuart is absent, his presence superfluous. As 6,100 diners begin to queue up, the servers don gloves, hats, and aprons. At noon Stuart materializes. He mounts the stage and grabs the mike. He thanks everyone who made the banquet possible, calls food waste a scandal, briefly links agriculture to climate change, then withdraws from the stage. But not before shouting, *"Bon appétit."* □

National Geographic's food blog, **The Plate,** explores the global relationship between what we eat and why. Get your serving of the science, history, and culture of food at *theplate.nationalgeographic.com.*

THE COLD

RUSH

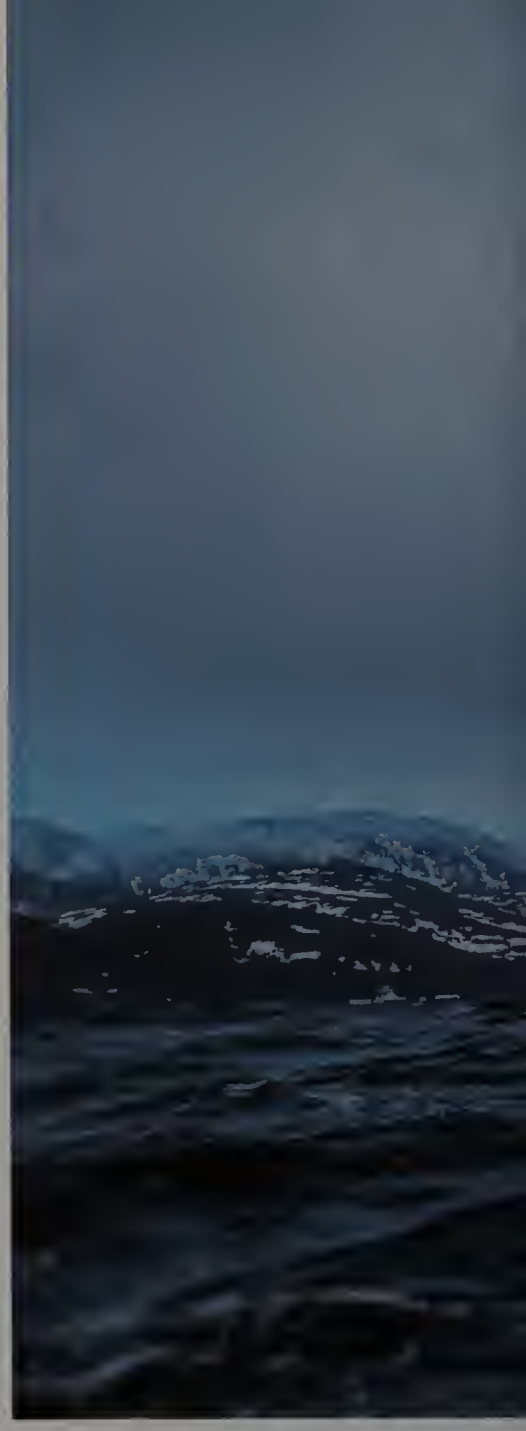
The Arctic is thawing rapidly, but it's still a brutal place to work. In the rush to tap its resources, there are no easy profits.

Roughnecks arrive by chopper for their weeks-long shifts at the Trebs and Titov oil fields in the Russian Arctic, west of the Yamal Peninsula. Traditional home of native reindeer herders, the region is now dominated by companies pumping oil and gas.

Floodlights replace the sun during the long polar night at Bovanenkovo, Russia's newest natural gas field on the remote Yamal Peninsula. Discovered in the early 1970s, the giant deposit was deemed too expensive to develop until President Vladimir Putin made it a priority.

A member of a drilling crew at Bovanenkovo relaxes in the trailer he shares with up to three other men. Most drillers are contractors for Gazprom, the state-owned oil and gas company. They work through the winter, when outside temperatures can fall below minus 50°F.

By Joel K. Bourne, Jr.
Photographs by Evgenia Arbugaeva



A few days before Christmas in 2014 a familiar face flickered to life in a conference room at Bovanenkovo, 250 miles north of the Arctic Circle on the Yamal Peninsula of Siberia. Vladimir Putin looked a little pixelated from the satellite uplink. Alexey Miller, CEO of Russia's energy giant Gazprom, stood stiffly facing the screen and the Russian president. Outside the room the clusters of prefab buildings and shiny pipes were lit up like a space station floating in the darkness. Bovanenkovo is one of the largest natural gas deposits on Earth. Miller asked Putin for the order to start pumping from a new field there.

"You may begin," said Putin.

Miller relayed the message; an engineer tapped a key. With that, Arctic gas began flowing down a 700-mile pipeline into Russia's sprawling network. The Yamal Peninsula, a thumb of flat tundra jutting north into the frozen Kara Sea, was known until recently for its nomadic reindeer herders, the Nenets, and under Joseph Stalin for its brutal prison camps. But by 2030, Gazprom estimates, the region will supply more than a third of Russia's gas production and a lot of its oil. Bovanenkovo is one of more than 30 known gas and oil deposits on the peninsula or just offshore. Yamal could become an Arctic Saudi Arabia funneling hydrocarbons to an energy-hungry world. Or so Putin hopes.

As global warming thaws the Arctic, Russia is leading the rush to exploit the region's resources. In late 2013, on a platform in the Pechora Sea, Gazprom became the first company to produce oil offshore in the Arctic, after jailing 30 Greenpeace protesters and confiscating their ship. On the east side of Yamal a partnership led by another Russian company, Novatek, is building a giant terminal to liquefy gas and export it to East Asia and Europe by ice-breaking tanker—though over time there may be less and less ice to break.

Russia is not alone. More than a fifth of the world's conventional oil and gas that has yet to be discovered lies above the Arctic Circle, according to a 2008 estimate by the U.S. Geological Survey, and the region is rich in other minerals too. Last year Norway anchored an oil platform in the Barents Sea even farther north than Gazprom's platform. Canada is mining diamonds, gold, and iron in the Northwest Territories and Nunavut. And with the Siberian coast now ice free for several months each year, cargo ships

The new *Goliat* platform awaits commissioning in a fjord near Hammerfest, Norway, last April. Now moored in the Barents Sea at 71° north, it's the world's northernmost offshore oil platform.

have begun navigating along the Northern Sea Route between Europe and East Asia. This summer a large cruise ship, the *Crystal Serenity,* is scheduled to carry tourists through Canada's legendary Northwest Passage.

The Arctic rush seems inevitable—and worrying. Thawing permafrost already is releasing planet-warming carbon into the atmosphere; if we want climate change to stay manageable, according to one recent study, Arctic oil and gas are high on the list of hydrocarbons we should leave in the ground. Environmentalists also fear the impact of development on a wilderness with spectacular wildlife. And many of the four million indigenous people who live around the Arctic worry about the threat to their way of life, though others welcome the jobs and tax revenues that development may bring.

Given the hype on both sides of the argument, what's striking is how patchy the Arctic rush actually is. Few companies have dipped their toes into Arctic waters, and fewer still are making a profit. Last fall Royal Dutch Shell abruptly abandoned its multiyear, seven-billion-dollar effort to extract oil from the Chukchi Sea off Alaska after

Harsh Frontier

Although the Arctic has huge energy and mineral resources, extracting them is arduous. A decade ago, with sea ice melting and commodity prices high, there was a surge in investment. Now prices are low. Ice is still melting, but conditions in the Arctic remain harsh, and infrastructure is lacking. Russia, with its 25,000-mile Arctic coastline and long history in the region, has the biggest commitments and ambitions.

Sea

- Exclusive economic zone boundary *200 nautical miles*
- International maritime boundary
- Boundary of overlapping claim
- Shipping lane
- Lease

Safety

- Arctic nation Rescue Coordination Center (RCC)

Active Oil and Gas

Norway and Russia now operate offshore platforms. Russia depends on oil and gas revenues and exports; it needs Arctic fields to replace aging ones in western Siberia.

- Gas pipeline
- Oil pipeline
- Field
- Area with at least a 50 percent chance of having recoverable oil and gas

Mines

The Arctic region is rich in such minerals as phosphate, bauxite, diamonds, iron ore, and gold. Access to some is getting harder as the ice-road season gets shorter.

- Commodity mine

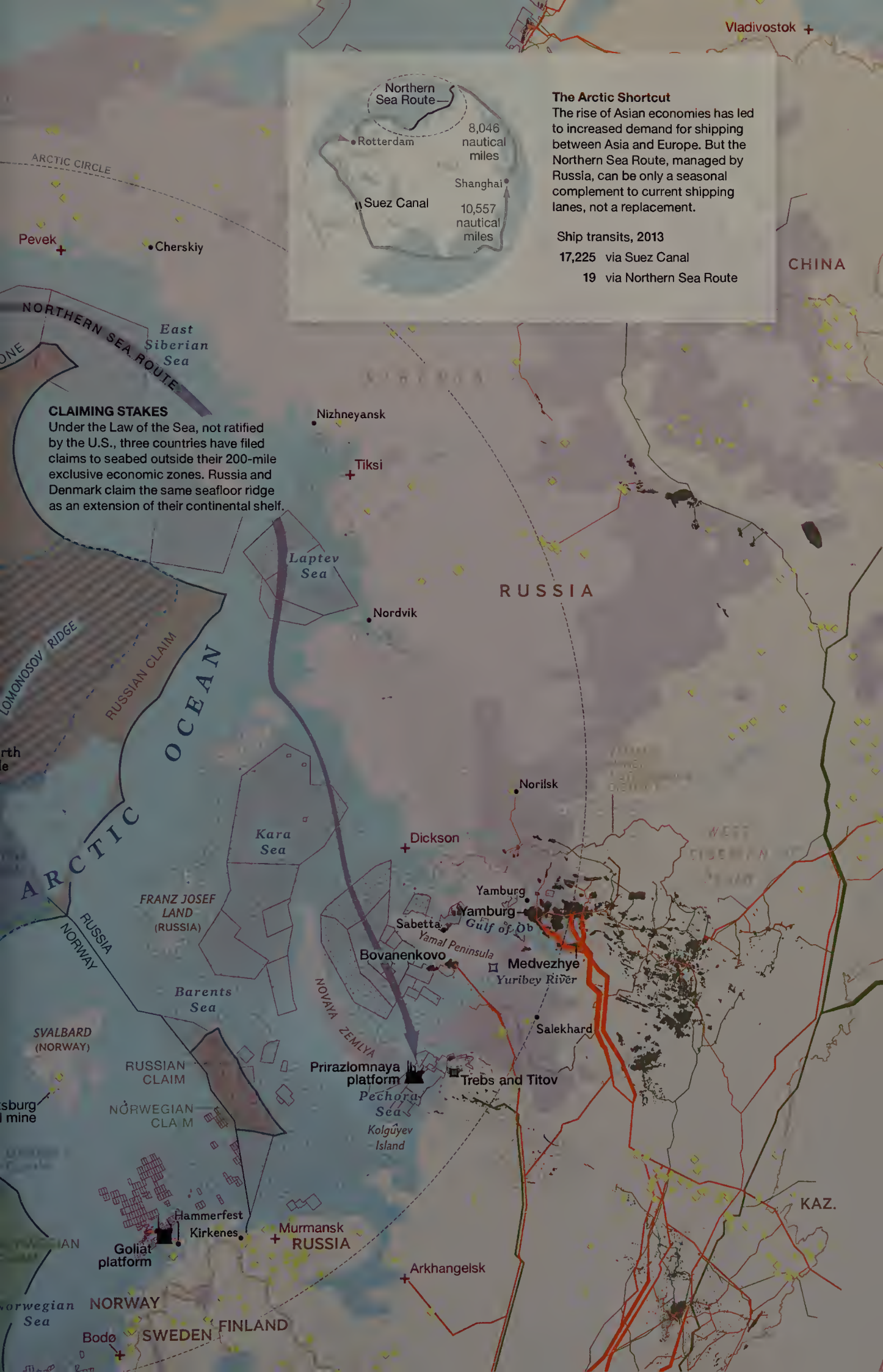
Permafrost

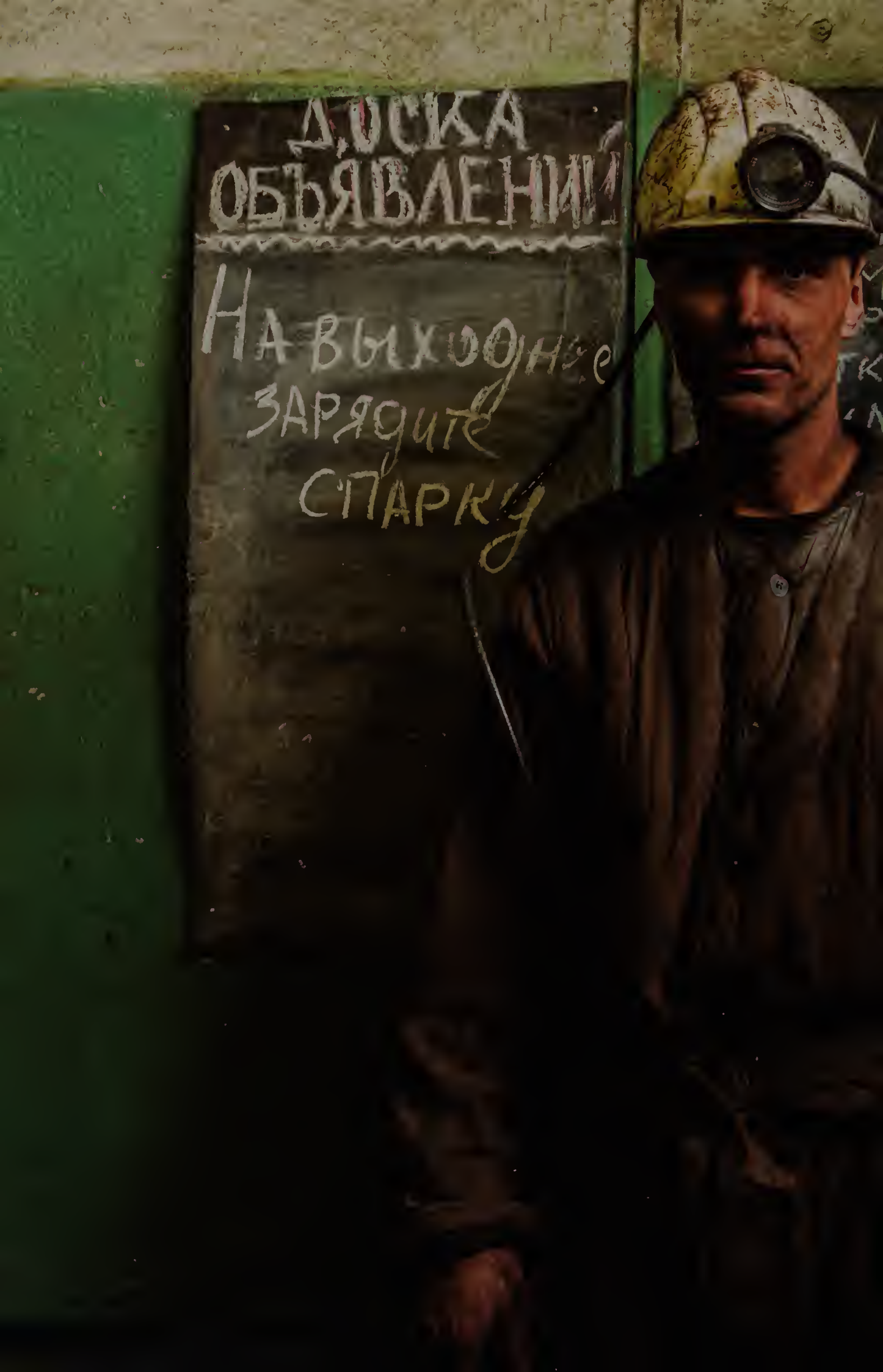
Permafrost is shrinking; models predict close to a 50 percent decline by 2100.

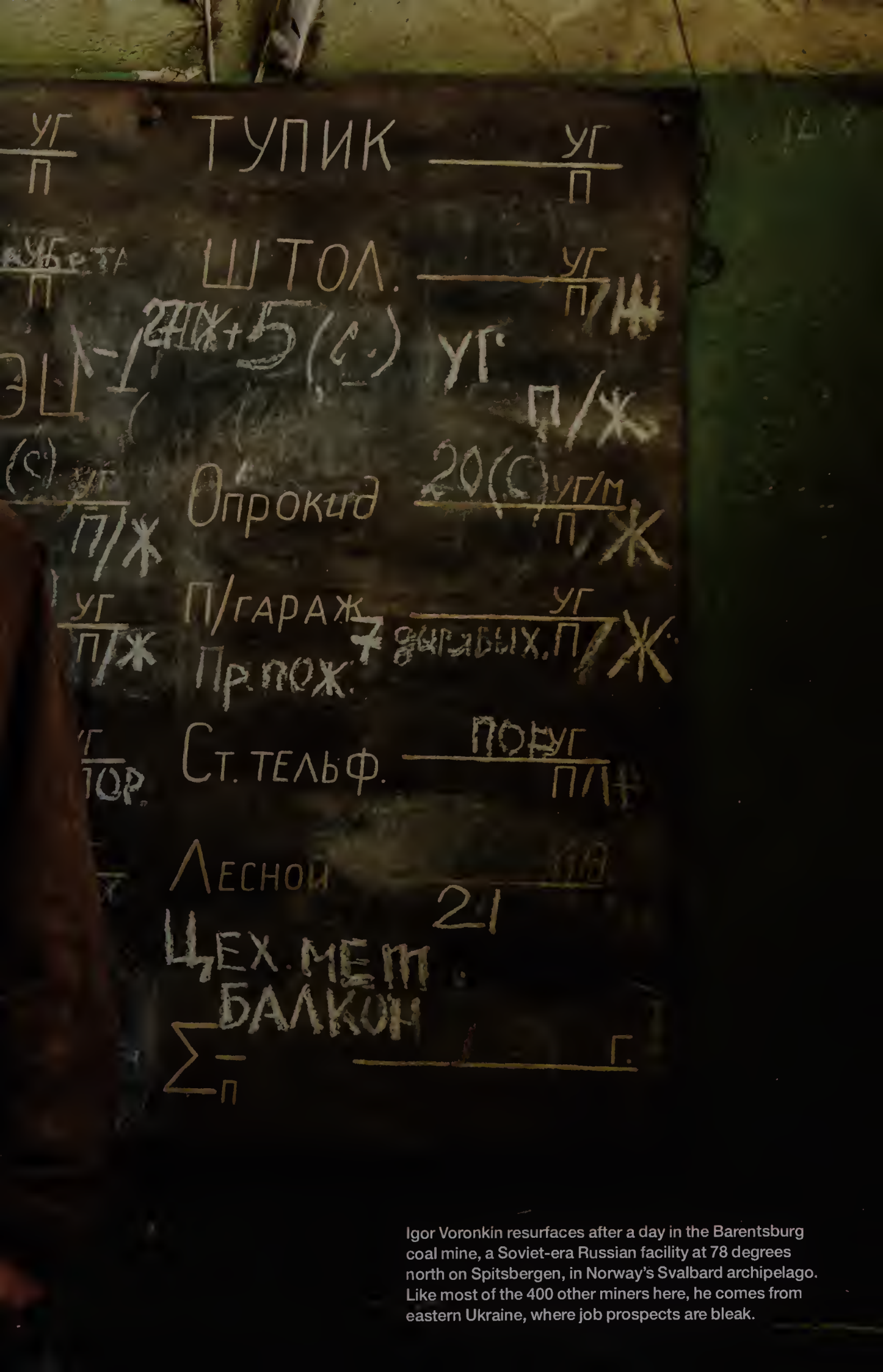
- 2020 extent
- 2100 extent

SEA ICE NOT SHOWN

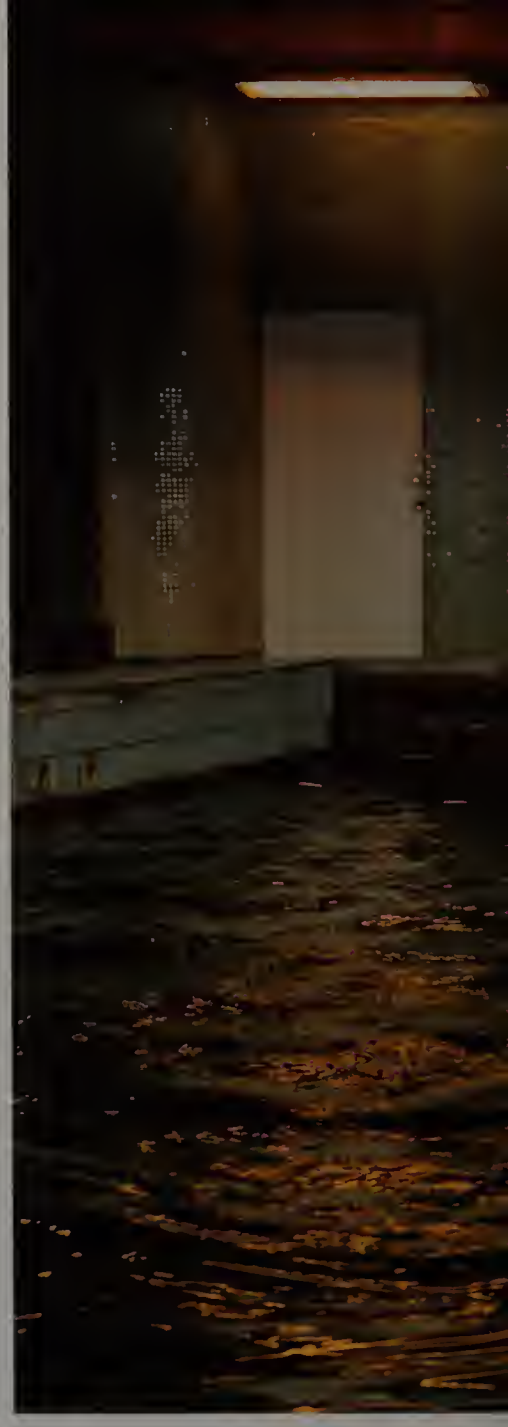
LAUREN E. JAMES AND RYAN WILLIAMS, NGM STAFF. SOURCES: IHS ENERGY; IBRU, DURHAM UNIVERSITY, U.K.; USGS; GEOLOGICAL SURVEY OF FINLAND; NATURAL RESOURCES CANADA; ALBERT BUIXADÉ FARRÉ, INSTITUTE FOR GLOBAL MARITIME STUDIES; INTERNATIONAL MARITIME ORGANIZATION; CHARLES KOVEN, LAWRENCE BERKELEY NATIONAL LABORATORY


Vladivostok
Northern Sea Route
Rotterdam
8,046 nautical miles
Shanghai
Suez Canal
10,557 nautical miles
The Arctic Shortcut
The rise of Asian economies has led to increased demand for shipping between Asia and Europe. But the Northern Sea Route, managed by Russia, can be only a seasonal complement to current shipping lanes, not a replacement.
Ship transits, 2013
17,225 via Suez Canal
19 via Northern Sea Route
ARCTIC CIRCLE
Pevek
Cherskiy
CHINA
NORTHERN SEA ROUTE
East Siberian Sea
CLAIMING STAKES
Under the Law of the Sea, not ratified by the U.S., three countries have filed claims to seabed outside their 200-mile exclusive economic zones. Russia and Denmark claim the same seafloor ridge as an extension of their continental shelf.
Nizhneyansk
Tiksi
Laptev Sea
RUSSIA
Nordvik
LOMONOSOV RIDGE
RUSSIAN CLAIM
ARCTIC OCEAN
Norilsk
Kara Sea
Dickson
Yamburg
Yamburg
Gulf of Ob
Sabetta
Yamal Peninsula
FRANZ JOSEF LAND (RUSSIA)
RUSSIA
NORWAY
Bovanenkovo
Medvezhye
Yuribey River
Barents Sea
NOVAYA ZEMLYA
Salekhard
SVALBARD (NORWAY)
RUSSIAN CLAIM
Prirazlomnaya platform
Trebs and Titov
NORWEGIAN CLAIM
Pechora Sea
Kolguyev Island
KAZ.
Hammerfest
Kirkenes
Murmansk
RUSSIA
Goliat platform
Arkhangelsk
NORWAY
Norwegian Sea
SWEDEN
FINLAND
Bodø


ДОСКА
ОБЪЯВЛЕНИЙ
НА ВЫХОДНЫЕ
ЗАРЯДИТЕ
СПАРКУ



Igor Voronkin resurfaces after a day in the Barentsburg coal mine, a Soviet-era Russian facility at 78 degrees north on Spitsbergen, in Norway's Svalbard archipelago. Like most of the 400 other miners here, he comes from eastern Ukraine, where job prospects are bleak.



drilling a single unpromising hole. Record-low oil prices likely contributed to the decision. So did the astronomical costs of operating in a region where infrastructure is sparse, distances are huge, and the weather remains horrific.

Shortly before Putin opened the new gas field on Yamal, a large Korean factory trawler probing for pollack in the northern Bering Sea sank in heavy weather, taking more than 50 crew members with it. The closest Coast Guard cutter was 580 miles away in Dutch Harbor in the Aleutians. That same outpost is more than a thousand miles from Alaska's north coast, where oil rigs have been operating—and a cruise ship will soon. "The *Crystal Serenity* will have 1,700 people aboard," said Charles D. Michel, vice commandant of the U.S. Coast Guard, at a conference in Anchorage last year. "This keeps me up at night. As a Coast Guardsman, I don't want a repeat of the *Titanic* on my watch. But [a rescue] would be a very complex operation. It's a very difficult area with difficult weather."

RUSSIA: MANIFEST DESTINY

On a snowy December evening, with the temperature at minus 4°F, a few dozen spitting and swearing gas-field workers shuffle around outside the trailers that pass for a railway station near Salekhard, capital of the Yamalo-Nenets Autonomous District. They're waiting for a commuter train that will carry them deep into the Arctic. To get workers to Bovanenkovo, Gazprom had to build its own 355-mile railroad, including a two-mile-long trestle over the Yuribey River. The commute takes 24 hours, but some of the riders have traveled for three days just to reach Salekhard. In the field they live four to a room in cozy dorms, working 8 a.m. to 8 p.m. in month-long shifts. They have a gym, a game room, and a salt spa that's supposed to help them recover from the dry Arctic air. When their shift is over, they head "back to Earth," as if they were cosmonauts mining the moon.

"This routine is not for everyone," says Pavel Dmitrievich Bugayev, a veteran commuter from Nizhniy Novgorod, a thousand miles to the southwest. "The job is difficult, but the pay is good and comes with many social benefits. My wife sometimes complains that life is hard without me, but it's not like it used to be when I'd vanish for a month. We are now connected via the Internet and Skype."

Russia's fascination with the Arctic and its potential riches dates at least to Peter the Great, whose desire to map the coast of Siberia led to the Great Northern Expedition of the 1730s and '40s. Vladimir Putin is continuing that tradition of manifest destiny, going so far as to claim nearly half a million square miles of the Arctic Ocean. According to Russian oil and gas experts, he has little choice. Ninety percent of the nation's estimated gas reserves and 60 percent

A Barentsburg miner swims at the company pool after a day of dangerous work. Scores of miners have died since the mine opened a century ago. It loses money but remains a strategic Russian outpost.

of its oil reserves lie in the Arctic or subarctic.

"Russia's current predicament is very simple," says Konstantin Simonov, director of the Moscow-based National Energy Security Fund. "Gas fields discovered in the 1960s laid the foundation for Russia's decades-long dominance of the global natural gas market. Now these Soviet-era giants are in decline. Moving farther north into the Arctic is the next logical step."

It's not an economical step right now, with oil and gas prices so low. "If you just looked at the economics of some of these projects, you'd never do it," says James Henderson, a Russia scholar with the Oxford Institute for Energy Studies in England. "But Russia is focused on development of the far north, and the best way to do that is to encourage the oil and gas industries to go there."

Bovanenkovo is the first big project on the Yamal Peninsula. The most ambitious project there is the liquefied natural gas (LNG) facility at Sabetta, on the Gulf of Ob. One of the world's largest, it's being built by Russia's Novatek with the help of French oil and gas giant Total and the Chinese National Petroleum Company. The Russian government is contributing

Frozen Fortunes

The Arctic may hold as much as 16 percent of the world's undiscovered oil resources, most of it offshore. Yet the challenges of operating in such an unforgiving environment are hampering a predicted oil boom. Several oil companies recently shelved offshore exploration plans, leaving only two platforms currently producing oil in the frigid waters.

PERMAFROST AND PIPELINES
Most Arctic oil pipelines are designed to use permafrost as a foundation. But that foundation is thawing and sagging as the Arctic warms, making pipelines and other infrastructure vulnerable to buckling and rupturing.

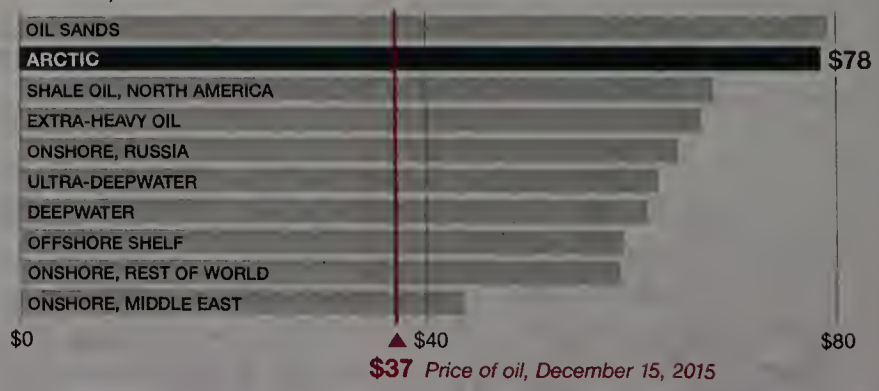
ICE ROADS
Arctic oil operations are heavily dependent on wide ice roads that can support thousand-ton drilling rigs as well as heavy trucks that deliver supplies. The trucking season has decreased by 24 percent since 1969 because of shorter winters.

OFFSHORE OIL PRODUCTION

Prirazlomnaya (Gazprom)
The Arctic's first offshore platform, and the only one operating year-round, began producing oil in late 2013 in the Pechora Sea off Russia. Standing on a man-made island in shallow water, it's able to withstand shifting sea ice.

THE HIGH PRICE OF ARCTIC OIL
Arctic oil is expensive to produce. Its break-even price—the price required to cover the cost of production—is exceeded only by that of oil sands, such as those in Canada, which require large amounts of energy to separate oil from sand.

Break-even price of known but undeveloped oil reservoirs
Per barrel, 2015



ROUGH CONDITIONS

Operating in the Arctic means enduring long spells of darkness and extreme conditions. Powerful storms, high seas, low temperatures, and dangerous winds can limit working outdoors to two hours at a time.

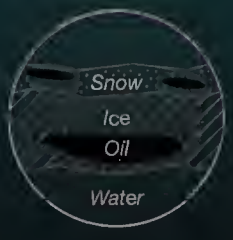
***Goliat* (Eni, Statoil)**
This platform, the largest in the Arctic, anchored 53 miles off Norway's coast in the Barents Sea, began pumping oil last year. Its round shape blunts the impact of strong winds and waves.

***Polar Pioneer* (Shell)**
In August 2015 Shell drilled in the Chukchi Sea off Alaska but failed to find sufficient quantities of oil. In September it suspended its Arctic program "for the foreseeable future."

OIL SPILLS

The cleanup procedures that are standard in warmer climes—containment booms and chemical dispersants—are challenging to deploy in Arctic waters. Government and industry have done tests but have not yet confronted a major offshore spill.

A Winter Spill
Oil spilled in winter can get trapped in ice and snow. This can help contain the spill, but the polluted ice must be tracked.



The Following Summer
As the ice begins to melt, the trapped oil migrates upward to the surface, where it can contaminate meltwater pools that attract wildlife.

1,312 feet

1,640 feet

1,000

1,500

JASON TREAT AND RYAN WILLIAMS, NGM STAFF; AILEEN CLARKE. ART: NICK KALOTERAKIS

SOURCES: RYSTAD ENERGY; GAZPROM; ROYAL DUTCH SHELL; STATOIL; ALASKA DEPARTMENT OF NATURAL RESOURCES; USGS; NATIONAL RESEARCH COUNCIL

In 2010 the frame of a house-size truck cracked. Steel

a deepwater port and the services of a few of the icebreakers in its enormous fleet—40 now and 10 more in the works—to assist the dozen ice-breaking LNG tankers that are being built for the project. Putin wants those tankers moving for as much of the year as possible. Even though the $27 billion project won't come online until at least 2018, Novatek has presold a lot of the gas.

Russia is even more focused on Arctic oil. Production taxes and export duties on oil provide 40 percent of its government revenue (only 10 percent comes from gas), and its legendary oil fields in western Siberia are declining. So far, however, it has needed foreign technology and capital to drill offshore in the Arctic, and sanctions imposed after its intervention in Ukraine have temporarily shelved such projects. Gazprom's Prirazlomnaya platform is the only one producing oil. But just before the sanctions took effect, ExxonMobil and Russian oil giant Rosneft drilled the world's northernmost well, in the Kara Sea. They struck oil—an estimated 700 million barrels—but have capped the well for now.

There are no pipelines near these fields. The oil from Prirazlomnaya—some five million barrels so far—is siphoned off by shuttle tankers and sometimes transferred to other ships. This greatly increases the risks of spills, and Russia's track record on land isn't reassuring. According to local environmental groups, Russian companies have spilled more than three and a half million barrels of oil on the tundra.

NORWAY: BOOM ON THE BARENTS

In September 2010 the M.V. *Nordic Barents* loaded iron ore at the Sydvaranger mine in Kirkenes, Norway, and sailed east to Shanghai. The first non-Russian commercial vessel to travel the Northern Sea Route, it was escorted by a Russian icebreaker, but it met little ice, never stopped, and averaged more than 12 knots. More important, it made money. The Arctic shortcut shaved a third off the route through the Suez Canal and saved $180,000 in fuel alone.

In 2013 a Chinese container ship, the *Yong Sheng,* beat the travel time through Suez by nearly two weeks, sailing from Dalian to Rotterdam in a record 35 days. Some claim the long-sought Arctic sea route is finally a reality.

"I was in a meeting with the general director of Atomflot [Russia's ice-breaking fleet] a few years ago," says Felix Tschudi, whose company, Tschudi Shipping, organized the pioneering voyage of the *Nordic Barents.* "He was a big man, and he said, 'We want to compete with Suez!'" The Russian slammed a meaty fist on the table.

That's wishful thinking, Tschudi says. More than 17,000 ships pass through the Suez every year, compared with 19 full transits of the Northern Sea Route in 2013. Even as Arctic ice retreats, ill winds still blow floes and "growlers"—small icebergs—into sea-lanes, causing costly delays. The Russian route is free of pirates at least. But it's still too seasonal and too far north for the bulk of the world's trade.

It's a direct route, however, to and from Siberia itself. Tschudi's company has transferred Siberian oil from ice-breaking shuttle tankers to traditional tankers at Kirkenes; it has delivered crushed stone to the LNG construction site at Sabetta. That's the model for Arctic shipping, Tschudi says: Bring natural resources out of Siberia, and send building materials and consumer goods deep into the region via its rivers. So confident is Tschudi that he bought the Sydvaranger mine mostly for its port. He sees it becoming the Rotterdam of the north.

Meanwhile the old fishing town of Hammerfest, 160 miles west of Kirkenes, has become the center of Norway's own Arctic oil and gas ventures in the Barents Sea. Statoil, the Norwegian oil and gas company, built Europe's only LNG facility here in 2007. It receives gas from three offshore fields through an 89-mile-long undersea pipeline.

"Hammerfest was on its way to being a ghost town," said the cabdriver who picked me up at the airport. "Our history is now divided into the time before the gas plant and the time afterward. The day they started building it, every stairway in town had a person on every step."

The day I arrived was another big one for Hammerfest. The harbor was full of ships

beams as big as tree trunks get brittle at minus 40°F.

waiting to tow what appeared to be a round orange island out to sea. The *Goliat* platform, which belongs to the Italian oil company Eni and Statoil, has since dropped anchor at 71 degrees north—53 miles northwest of Hammerfest and 140 miles closer to the North Pole than Russia's Prirazlomnaya platform. Twenty-five stories tall, *Goliat* can pump 100,000 barrels of oil a day and store a million barrels in its bright orange hull until tankers retrieve it. Thanks to the Gulf Stream, this part of the Barents Sea stays largely ice free, leading Eni officials to dub it the "workable Arctic." But the platform still has to withstand hurricane-force winds and 50-foot waves. Its novel round hull bobs like a cork.

Eni has contemplated a string of *Goliats* tapping even larger fields farther north in the Barents—but the price of oil has undermined that vision. *Goliat* cost $5.5 billion and was $1.3 billion over budget. Industry analysts estimate the company needs an oil price of $95 a barrel—roughly double the price in late 2015—to break even. Frederic Hauge, founder of the Bellona Foundation, a Norwegian environmental group, hopes low oil prices will scuttle Eni's grand plans and other offshore projects in the Arctic. There's still no good way to clean up oil spilled in Arctic waters, he says.

Most residents of Hammerfest, however, seemed glad to have the *Goliat* out there. The town was booming, with new, brightly colored apartment buildings, schools, and a cultural center. Fishermen worry more about an invasion of cod-egg-eating crabs than about an oil spill from the *Goliat,* says Jacob West, leader of the fishermen's union. Eni has trained 30 local captains to skim oil if necessary. "This is our garden," West says. "We know the area and the weather, so fishermen are the best to do the job."

The day I left, he and his colleagues were scheduled to conduct a large oil-spill drill. It was canceled because of bad weather.

CANADA: A GOLD MINE FOR NUNAVUT

The Meadowbank gold mine, northwest of Hudson Bay in the sprawling territory of Nunavut, is one of the coldest mines on Earth. Shortly after it opened in 2010, workers were loading a house-size dump truck with ore when the massive frame cracked. Apparently even steel beams as big as tree trunks get brittle when temperatures drop below minus 40°F.

It was nearly that cold when I arrived last March in a van full of mine workers from Baker Lake, the nearest settlement. In the middle of the two-and-a-half-hour drive, the van pulled over to let its passengers have a bathroom break and a smoke. A treeless, boulder-strewn field of snow stretched to the horizon. The slight breeze stung like invisible sleet. Even a nonsmoker could see the appeal of a small fire in front of one's face. But deep breaths of any kind, or exposing sensitive bits of one's anatomy, seemed like a bad idea. The week before I arrived, a blizzard had cut off the mine for three days. Arctic warming hasn't helped much at Meadowbank.

The cold isn't the only challenge. One night in 2011 a hungry wolverine burrowed beneath the camp kitchen to get at the grease. The ensuing electrical fire burned down the cafeteria, slowed mining significantly for weeks, and caused U.S. $18 million in damages. But the utter lack of infrastructure and energy was the biggest hurdle, says Sean Boyd, CEO of Agnico Eagle, the Toronto-based mine owner. Agnico Eagle had to build an airstrip capable of landing a Boeing 737 at Meadowbank and a 65-mile, all-weather road to the mine. When something big breaks, such as a hundred-ton truck, Agnico Eagle has to charter a C-130 Hercules to fly in massive parts or wait for Hudson Bay to thaw in summer.

"We underestimated the work and the cost of the logistics involved in building something in the middle of nowhere," Boyd says. "It ended up being double our initial estimate. Energy is a huge component of the cost." The mine, he explains, burns 9 to 12 million gallons of diesel a year in six 6,000-horsepower generators. Tanker trucks deliver the fuel daily from Baker Lake, where it arrives by barge each summer through Hudson Bay.

The mine itself occupies nearly six square miles. During the brief Nunavut summer its three open pits become inverted islands, below

In 2010 the Meadowbank gold mine opened in Canada's mineral-rich Nunavut, an immense territory with 37,000 inhabitants. Some 400 of them work at the mine. A dike keeps it from flooding in summer, when the tundra thaws into lakes and bug-infested bogs.

the deep indigo lakes that surround them and protected by an earthen dike. The lakes are full of trout, arctic char, and grayling. Mining waste rises in a 200-foot-high mesa. After it's capped with 13 feet of clean soil, the mine's engineers say, the waste mountain will freeze permanently, preventing acids and heavy metals from leaching into the lakes during the sparse summer rains.

Though Meadowbank's ore contains three times the gold concentration of most open-pit gold mines, by 2013 the company had lost more than a billion dollars on the venture and had only five more years of ore left to mine. A new find about 35 miles away may extend the operation another decade and allow it to turn a profit.

But like Hammerfest, Baker Lake, population 1,900, has benefited. In the 1950s the Canadian government relocated many Inuit to villages like Baker Lake to provide them schools, health care, and other services. The transition hasn't been easy. Many Inuit live on public assistance, with two or three families sharing a two-bedroom house. A third of Nunavut's population of 40,000 doesn't get enough to eat, according to a 2015 Canadian government report. Alcoholism, drug abuse, and sexual assault are common. The suicide rate among young men is 40 times the Canadian average.

Local leaders say turning Nunavut into Canada's new mining district could help. An iron mine opened on northern Baffin Island in 2014, and elsewhere in Nunavut diamond, gold, and uranium mines are planned. Mines offer plenty of jobs for unskilled workers, from housekeepers to cooks to truck drivers. Before Meadowbank came to town, the unemployment rate in Baker Lake was 30 percent. Today almost anyone who wants a job can find one; the mine employs some 300 Inuit.

"Resource development has done more for my community than I ever could imagine," says Peter Tapatai, a 63-year-old businessman from Baker Lake who handles transportation for the mine. "When you see a young man and woman working, they're now part of Canada. They are breadwinners. Our people had no future other than lining up to get welfare checks. Now every Thursday they line up for a paycheck."

Saving every speck, a Meadowbank metallurgist cleans molds of gold that will harden into blocks worth $700,000 each. Yet by 2013 the mine had lost more than a billion dollars. In the Arctic, costs explode.

Linda Avatituq, a 39-year-old single mother and grandmother, went to work in the mine three years ago. She had driven only a snowmobile before she took a job driving a massive yellow truck that hauls gold-bearing rock out of the pit. The job pays $80,000 a year. "My life changed a lot after I got the job," Avatituq says. "I sobered up after that. I can support my family and my grandkids. My grandson is six years

old. He wants to be a pilot." Tears roll down her cheeks. She misses him when she's at the mine.

A lot of Inuit and their families have trouble adjusting to the work schedule—two weeks on, two weeks off. The mine has hired counselors, and it sponsors square dances, badminton tournaments, and mine tours for spouses. Some workers, particularly young single women, have fled Baker Lake for the brighter lights of Winnipeg or Calgary. They fly in for their shift every two weeks just as their non-Inuit co-workers do.

Before I left the mine, I watched a gold pour. Metallurgists in white, heat-resistant suits and hoods slowly spilled the lavalike metal from a crucible into six molds, where it would cool to form silvery yellow bricks, each weighing 26 kilos (57 pounds) and worth about $700,000. "Who was the first person who decided gold was a valuable thing?" wondered a thoughtful mill operator. Over the centuries gold mines have dispossessed aboriginal people and wreaked ecological destruction all over the planet. This modern industrial mine dropped into the Arctic wilderness may be different, but even local supporters worry whether it will ultimately be a boon or a burden for the people of Nunavut.

"I can't imagine what my own child is going to do," says Alexis Utatnaq, an instructor at the local community college who prepares students for jobs at the mine. "Are we going to have more

On the Russian island of Kolguyev an oil field worker checks the level in a storage tank now owned by Urals Energy. Beyond the beach lies the Barents Sea. The field has been producing high-quality light crude since the mid-1980s. It's pumped offshore into waiting tankers.

teachers and doctors, or are we all going to be miners? Will anyone still know how to hunt?"

ALASKA: THE WELL THAT WASN'T

The U.S. Army Corps of Engineers' permafrost tunnel is a Cold War relic, a short mine shaft dug into a hill north of Fairbanks where researchers once studied ways to hide missiles. Today it's an uncanny record of Alaska's past climate, showing periods of freezing and thawing dating back more than 40,000 years. Hand-painted signs point to mastodon femurs, horns of steppe bison, and blades of grass as green as the day they froze 25,000 years ago. It smells like an ancient barnyard.

"That's the carbon bomb, baby," says permafrost researcher Thomas Douglas, referring to the pungent bouquet of thawing yedoma—old, carbon-rich permafrost. The world's permafrost contains as much as 1,600 gigatons of carbon, twice what's in the atmosphere. As permafrost thaws, it releases carbon, amplifying climate change. Near Bovanenkovo scientists recently discovered several large craters, some more than 200 feet deep, that may have been formed by methane erupting from thawing permafrost.

"This is what everyone is worried about," Douglas says. "The most recent paper estimated that 10 to 15 percent could be emitted by 2100. But 240 gigatons is still a crapload of carbon." Such an outgassing could make Alaska—and the rest of the world—a very different place.

Alaska is already changing fast. Thawing permafrost is undermining roads and buildings. Last summer 700 wildfires scorched five million acres of boreal forest in the worst fire season in decades; even treeless tundra caught fire. The loss of sea ice that has made offshore oil exploration easier also has exposed Alaska villages to powerful storms, flooding, and coastal erosion—more than 60 feet a year in some spots. A 2009 federal report estimated that 31 Alaska villages faced "imminent threats."

Wainwright, a base for Shell's operations in the Chukchi Sea, isn't one of them. But Enoch Oktollik, chief of maintenance at the local school and a former mayor, says the change is still obvious. "The last ten years you could notice it,"

REBECCA HALE, NGM STAFF

Photographer **Evgenia Arbugaeva** was born in Tiksi, a small port town in the Russian Arctic. Her work often focuses on capturing the remote places of her homeland and the people who inhabit them.

How did the Arctic environment influence this assignment? The darkness of winter nights was definitely a challenge. With only two hours of daylight, I had to plan every day wisely. Also, on one trip I had to wait a week for a blizzard to pass so I could safely helicopter to a gas field.

Gazprom workers at Bovanenkovo inspect a pipeline—part of a network that sends gas to towns across Asia and Europe. Profits and politics will decide how much of the Arctic's resources get tapped.

he says. "Young ice develops, but multiyear ice is depleting. Walruses are coming ashore by the thousands at Point Lay, because they're losing their ice habitat. Our grass around here is getting taller and greener. It's sort of alarming to see all these interactions."

When Shell abandoned its hunt for offshore oil in Alaska last year, environmental groups celebrated. "Big oil has sustained an unmitigated defeat," a Greenpeace leader told the *Guardian,* adding that "the people won." Yet the people of Arctic Alaska were decidedly torn. After decades of opposing offshore drilling to protect the bowhead whale hunts, which are among the last pillars of their ancient culture, many North Slope residents, including Oktollik, ultimately supported Shell's venture for the jobs and tax revenue it could bring. "I'd rather see no development, but we have no choice," Oktollik says.

What about climate change? I ask.

"The Inupiat have been adapting for thousands of years," he says, smiling. "We'll adapt to climate change." □

With reporting in Russia by Gleb Raygorodetsky

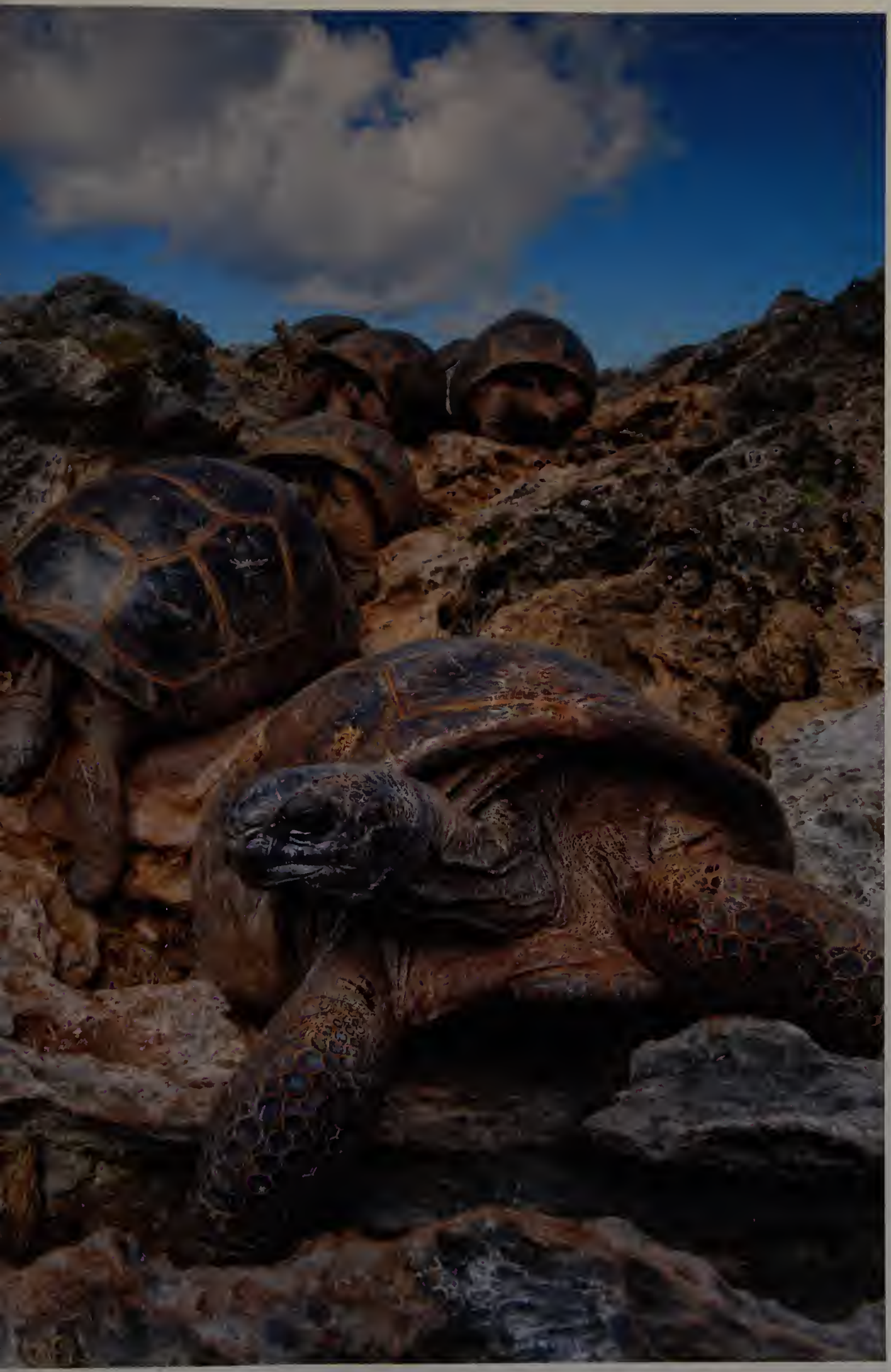
Return of the

Nature is getting a second chance on vulnerable islands in the Indian Ocean.

Lounging in inches of bath-warm water, blacktip reef sharks wait for the tide to refill the lagoon at remote Aldabra Atoll.

Seychelles

Aldabra giant tortoises escape searing daytime heat by taking refuge in caves within the rugged coral rock of the island of Grande Terre. It's a slow, cumbersome commute between the caves and the tortoises' grazing areas.



Privately owned St. Joseph Atoll was once commercially exploited for fish and coconuts but is now prized for its marine biodiversity and seabird colonies. In 2014 the island was made a nature reserve with a marine protected area. Its conservation is managed by the Save Our Seas Foundation.

Pitcher plants feed on insects that get trapped in their liquid-filled carafes. This endemic species survives on only two islands in Seychelles.

By Kennedy Warne
Photographs by Thomas P. Peschak

Nick Page, a genial New Zealander with a sunburned face and curly black hair, holds a photograph of Assumption Island's Most Wanted: a red-whiskered bulbul, a bird about the size of a cardinal with a black Mohawk crest and a fiery red tuft of feathers behind each eye. Since 2013, a team of conservation rangers have shot and netted 5,278 red-whiskered bulbuls on this four-square-mile comma of land 250 miles north of Madagascar. There is now one bulbul left.

Page has come within range of 5,279 twice, but bad luck prevented a shot. On the first occasion, a kite flew overhead, spooking his quarry, and on the second, a rainstorm struck. Such are the trials of the everyday sniper. But Page, a young conservation graduate, says that "with a bit of luck and lots of hiding," he'll nail the bulbul. He extends his thumb and grins, saying, "That's the size of the target."

Red-whiskered bulbuls are jaunty birds with a chattering song. Natives of Asia, they were brought to Assumption as pets by guano miners from Mauritius in the 1970s. Whether they escaped from their cages or were liberated is unknown, but the population exploded, and the pets became pests. The reason they're being eradicated isn't their presence on Assumption; rather it's their proximity to Aldabra, 17 miles across the Indian Ocean.

Aldabra is the westernmost of Seychelles' 115 islands and atolls and one of the world's most important nature reserves. Among its biological treasures is a native bulbul. Conservation managers fear that if the Asian immigrant colonizes the island, it will compete with the local bulbul and other native birds for limited food resources, prey on endemic invertebrates, and introduce the seeds of invasive plants.

To protect the jewels, you have to repel the invaders, eradication project leader Jessica Moumou tells me. "Red-whiskered bulbuls got to Aldabra once; they can do it again." The Seychelles Islands Foundation, which manages Aldabra, can't risk that, so it's tackling the

PHOTOGRAPHIC FIELDWORK WAS FUNDED IN PART BY THE SAVE OUR SEAS FOUNDATION.

problem at its source, on Assumption.

Bulbuls aren't the only birds the hunters have in their sights. The finchlike Madagascar fody, a bird so blazingly red it appears to be on fire, is also being extirpated. It too has a counterpart on Aldabra. In the early 2000s the foreign fody established a hundred-strong population on Aldabra before it was detected and extermination efforts began.

Killing a bird to save a bird may seem a perverse exchange—a misguided intrusion into nature's affairs. Ecological restoration of islands is sometimes criticized as being no better than the human interference that damaged island ecosystems in the first place. It plays God with nature—taking a piece out here, adding a piece back in there. (Other stories in *National Geographic*'s 2016 parks series, celebrating the centenary of the U.S. parks system, focus on the restoration theme too.)

Restoration ecologists see things differently, invoking the principle "You break it, you fix it." Humans introduced alien species, either intentionally or accidentally, and those species have altered island ecosystems, in some cases shattering them beyond recognition.

This is especially true when the newcomers are mammals. On isolated archipelagoes such as the Seychelles—and my own country of New Zealand—life evolved in the almost complete absence of mammals. (In both groups of islands, the only native land mammals are bats.) Island species cannot withstand the mammalian predation and competition that evolved on continents. Restoration seeks to level the ecological playing field. And sometimes the

Introduced as pets, ring-necked parakeets escaped into the wild and now threaten the national bird, the Seychelles black parrot, concentrated on Praslin island. Contract shooters are trying to wipe out the intruder.

Far-Flung Parks

Already successful in creating parks and reserves on half of Seychelles' land area, the government and its partners are now working to protect 30 percent of the 500,000-square-mile marine territory.

only way to do that is to remove the bullies from the schoolyard.

Ten days after I met Page, he shot the last red-whiskered bulbul.

WE LIVE, WE ARE TOLD, in the age of the sixth mass extinction, a human-induced spasm of species loss, a great redacting of the story of life. How do we reverse that trajectory? We could begin by reciting the opening words of the Seychelles Constitution: "We, the People of Seychelles, GRATEFUL to Almighty God that we inhabit one of the most beautiful countries in the world; EVER MINDFUL of the uniqueness and fragility of Seychelles... [declare our unswaying commitment] to help preserve a safe, healthy and functioning environment for ourselves and for posterity."

If this sounds like a conservation manifesto, so it should, for there is much in Seychelles to conserve, especially on the granitic islands in the east of the archipelago. These islands, where most of the 93,000 Seychellois live, are the mountaintops of a submerged landmass that split off the supercontinent of Gondwana along with India and Madagascar 125 million years ago, carrying with it an ancient biota.

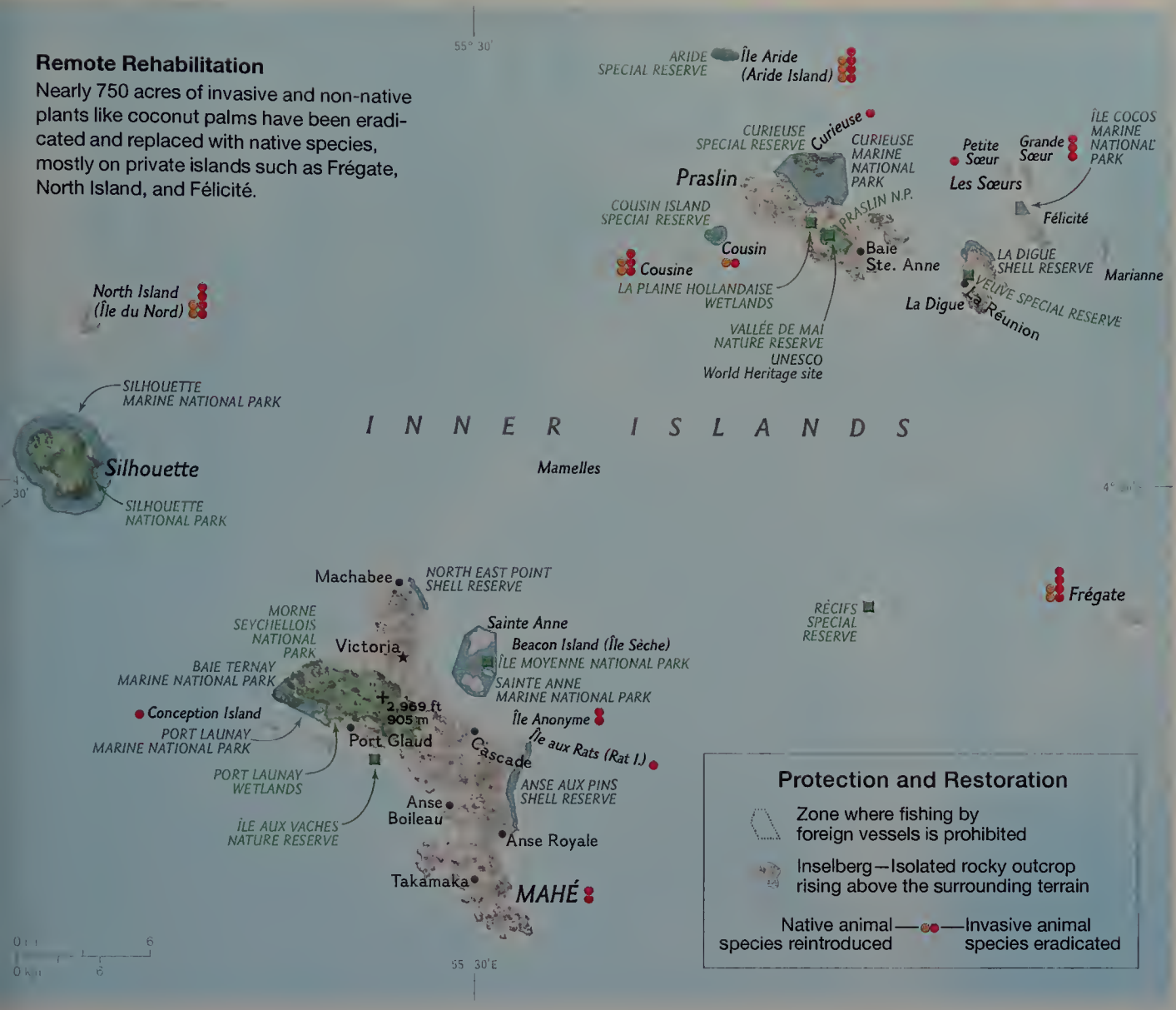
Eons of evolutionary isolation coupled with occasional injections of new biological capital have produced a cast of curiosities that includes frogs smaller than a fingernail and giant tortoises that weigh a quarter of a ton, a palm with a nut so large it would crush your skull if it fell on you and a tree whose seedpods look like jellyfish, a scorpion with praying mantis arms that whip out and snatch prey in a death grasp and land crabs the size of cats.

The easternmost of the granitics is Frégate,

MATTHEW W. CHWASTYK, NGM STAFF

Remote Rehabilitation

Nearly 750 acres of invasive and non-native plants like coconut palms have been eradicated and replaced with native species, mostly on private islands such as Frégate, North Island, and Félicité.



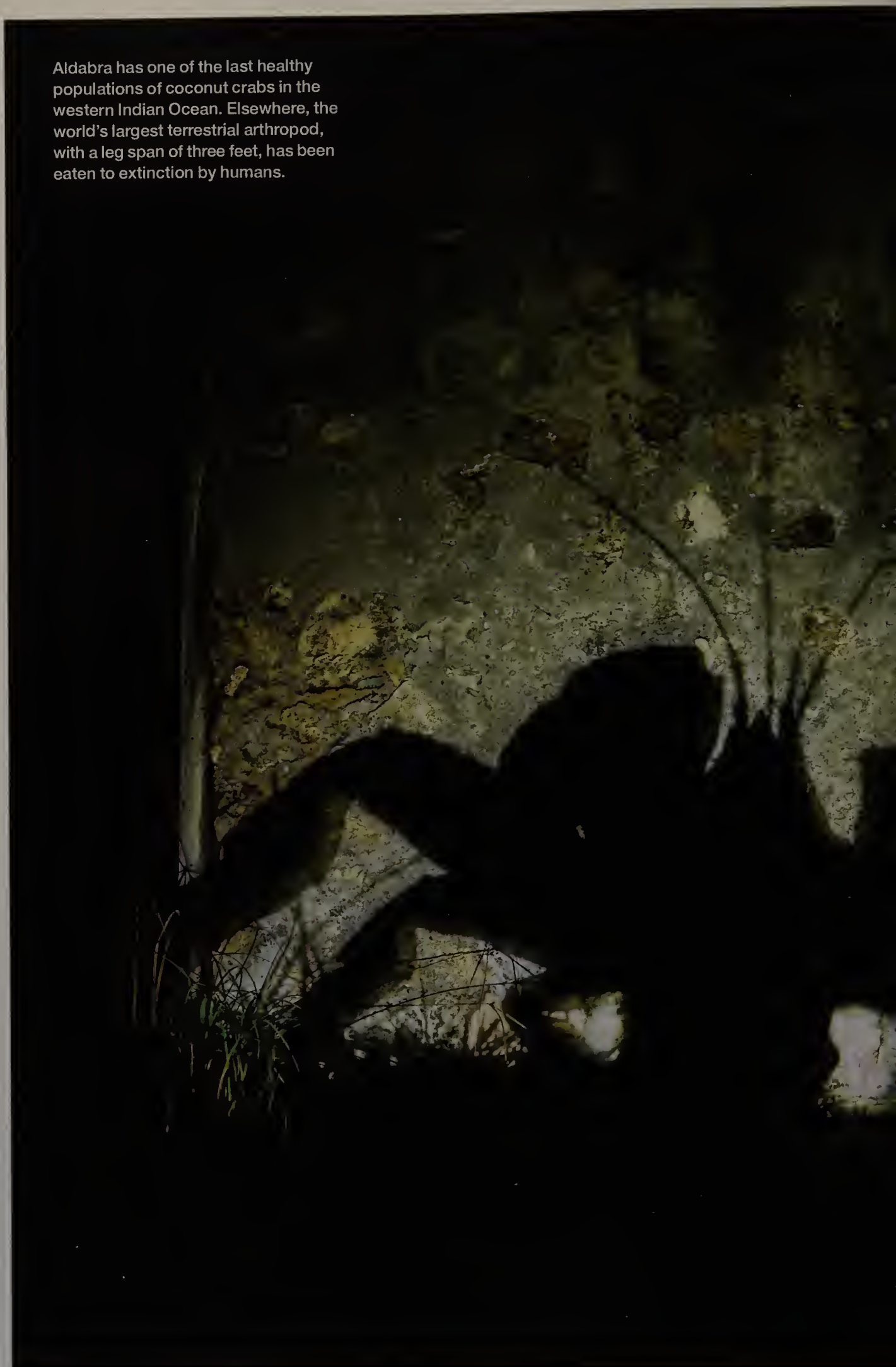
a privately owned island with a luxury resort and several creatures for which this island is a last resort. One of those species is the Seychelles magpie-robin, whose chic black-and-white plumage and inquisitive disposition have made it a local favorite. It was once widespread, but by the mid-1960s there were fewer than 15 alive, all on this island of less than a square mile. Conservationists launched a recovery program. Feral cats were eradicated. The robins were provided with nest boxes and supplementary food to boost their breeding chances. As numbers grew, birds were shifted to other predator-free island sanctuaries to spread the risk, and today the population has been coaxed up to several hundred.

No less important in Frégate's pantheon of relics are giant millipedes: glossy black, finger-thick, six-inch-long arthropods that cluster in knots on the trunks of trees and cross the island's roads with impunity. "I Brake for Millipedes" would make a good bumper sticker for the golf carts that resort guests use. The magnificent crawlers are most active after dark, so I joined Tanya Leibrick, the resort's conservation manager, for a night stroll through the forest. It was a slow walk, each step placed with care to avoid a fateful crunch. Scientists have calculated that one-fifth of the leaf litter that falls in the forest every 24 hours is consumed by hungry millipedes. In one spot we saw a dozen feasting on a fallen mango, like piglets at a trough.

Scanning a nearby log, our headlamp beams settled on a solitary gray-brown beetle with bumps on its abdomen like Braille and two tiny grappling hooks at the tip of each leg. I had been hoping to meet this insect, one of the world's largest tenebrionids, *(Continued on page 100)*

SOURCES: GÉRARD ROCAMORA, *INVASIVE ALIEN SPECIES IN SEYCHELLES*, ISLAND BIODIVERSITY & CONSERVATION CENTER, U. OF SEYCHELLES AND MUSÉUM NATIONAL D'HISTOIRE NATURELLE, BIOTOPE ÉDITIONS; ARJAN DE GROENE, GREEN IS. FOUNDATION; JOANNA SMITH, TNC CANADA; JUSTIN PROSPER, MINISTRY OF ENVIRONMENT AND ENERGY, SEYCHELLES; KATY BEAVER, PLANT CONSERVATION ACTION; PHILIP HAUPT, SEYCHELLES IS. FOUNDATION; RICK TINGEY, SPATIAL SUPPORT SYSTEMS

Aldabra has one of the last healthy populations of coconut crabs in the western Indian Ocean. Elsewhere, the world's largest terrestrial arthropod, with a leg span of three feet, has been eaten to extinction by humans.



Giant millipedes (above) and flightless beetles (top, numbered by scientists) were threatened when rats reached the island resort of Frégate in the mid-1990s. An international response restored the island to a rodent-free sanctuary. In Vallée de Mai, a World Heritage site on Praslin island, slugs (right) congregate to feed on the flowers of the coco-de-mer, a majestic native palm that bears the largest seed of any plant.

A white tern flits through regenerating native forest on Cousine, a private island off the coast of Praslin and one of Seychelles' ecological restoration successes. A luxury resort helps pay for the island's conservation projects.

or darkling beetles, found in the wild only on Frégate.

It's a wonder that this placid giant (over an inch long) survives. In 1995 an island conservationist's worst nightmare came to pass: Rats arrived on Frégate. The Seychelles name for the big beetle is *bib armé,* armored spider, but no amount of skeletal armor would have protected it—or the whip scorpions, snails, and other native invertebrates—from rodent teeth. In four years the beetle population plummeted by 80 percent.

An urgent call went out for international help to prevent an ecological collapse, and in 2000 Frégate was successfully de-ratted. Some of my countrymen were part of the effort, and the memory of that narrow escape, mingled with the sultry darkness of the forest, the whistling and cackling of noddies and terns in the treetops, the rustling of millipedes in the leaf litter, and this lone beetle, illuminated, seemed like an amazing grace.

A thin, pale blue snake showed itself at our feet, and Leibrick pulled away some leaves to reveal not a snake but a limbless amphibian called a caecilian, another Seychelles specialty. The pointy-headed animal whipped its body in violent twists and retreated into the safety of its burrow. Caecilians are thought to be part of the Seychelles' original cargo—creatures that made the long-ago raft trip from Gondwana. Such species are known as deep endemics, because their genetic lineage reaches back into ancient time. They make Seychelles very special indeed.

"NOT EVEN A HANDFUL of island groups have what Seychelles has," says conservation ecologist Christopher Kaiser-Bunbury. "Galápagos is a big name because of Darwin, but Seychelles is in no way inferior." I was climbing with Kaiser-Bunbury to look for jellyfish trees on Seychelles' main island, Mahé. As with many ecologically damaged islands, to find relict species you go high—to the mountaintops, beyond the reach of agriculture and habitation. We were scaling one of the granite outcrops known to scientists as inselbergs and to Seychellois as *glacis,* domes of reddish-gray rock, sculpted by the rainfall of millennia, that jut nakedly above the verdant forest.

Plants get a foothold in clefts and fissures in the granite, and much of what lives here is endemic, including the jellyfish tree, *Medusagyne.* Fewer than two dozen reproducing individuals of this singular species have been recorded—and only here, on the granite, where most other plants find the baking heat and scouring rain intolerable. For reasons no one is sure about, the seed rarely germinates in the wild—a big liability for a critically endangered plant. The specimen we found looked healthy but had just a few of the trademark pods that hang like tiny jellyfish amid shining green leaves. It will be a long road to recovery for the beleaguered species, here on the glacis—islands within an island, refuges for remnants from long ago.

LOWER DOWN THE MOUNTAIN, where glacis meets rain forest, we encountered a work crew slashing invasive vegetation and wrenching out young coco plum, guava, and cinnamon plants—which germinate only too easily—to help endemics such as carnivorous pitcher plants regain a foothold. Kaiser-Bunbury explained that the goal of restoration is rebuilding ecosystem integrity and functionality, not reverse-engineering a landscape that existed a hundred, or a thousand, or ten thousand years ago. It's not about slavishly re-creating the picture on an old jigsaw puzzle box, but letting the living pieces of a fragmented system reconnect themselves and recover their historic trajectory. "We help the system get back on track," he said. "We're not just gardening."

It's an idea whose time has come, just as biologist E. O. Wilson, the "father of biodiversity," predicted almost 25 years ago, saying this century would be "the era of restoration in ecology." It is capturing the imagination of Seychellois too. As realization of the country's biological richness sinks in, enthusiasm to protect it rises. Wildlife clubs are thriving in schools. "The young generation is getting into it," Terence Vel, the clubs' coordinator, told me. "Twenty years we've been working with the schools to pass those messages to them. We

High tide in Aldabra lagoon finds green turtles grazing on sea grass. Here and on other Seychelles islands, exploitation by humans has given way to admiration and a desire to protect and restore.

take them snorkeling and on field trips to show that we have a fragile ecosystem and must look after it for the next generation."

Some older Seychellois have been walking the restoration road for a while. On the granite slabs of Mahé, park ranger Terence Valentin, a Rastafarian who wears a T-shirt on his head to contain a mass of dreadlocks, told me: "I'm 19 years with the environment, brother. Ya, man, I am connected to the Earth!"

On Aldabra, the staff live that connection daily, on sea, on land, even inside their homes. Sunbirds build their nests on light fittings and shower rails, and steal the occasional necklace to decorate the nests. One giant tortoise that lives near the scientific station has figured out how to clamber up the steps for a drink of water.

Aldabra has more tortoises than Seychelles has people. Everything about these behemoths seems ancient, even the sound of their movements, which is like the creak of a leather saddle. Endemic birds called drongos hitch rides on their backs, watching for insects disturbed by the giants' lumbering passage. At night I listened to the sea breathing in the rocks and the tortoises snoring under the floorboards. "This place changes your life," Jude Brice, a boat skipper, said. "You see things differently."

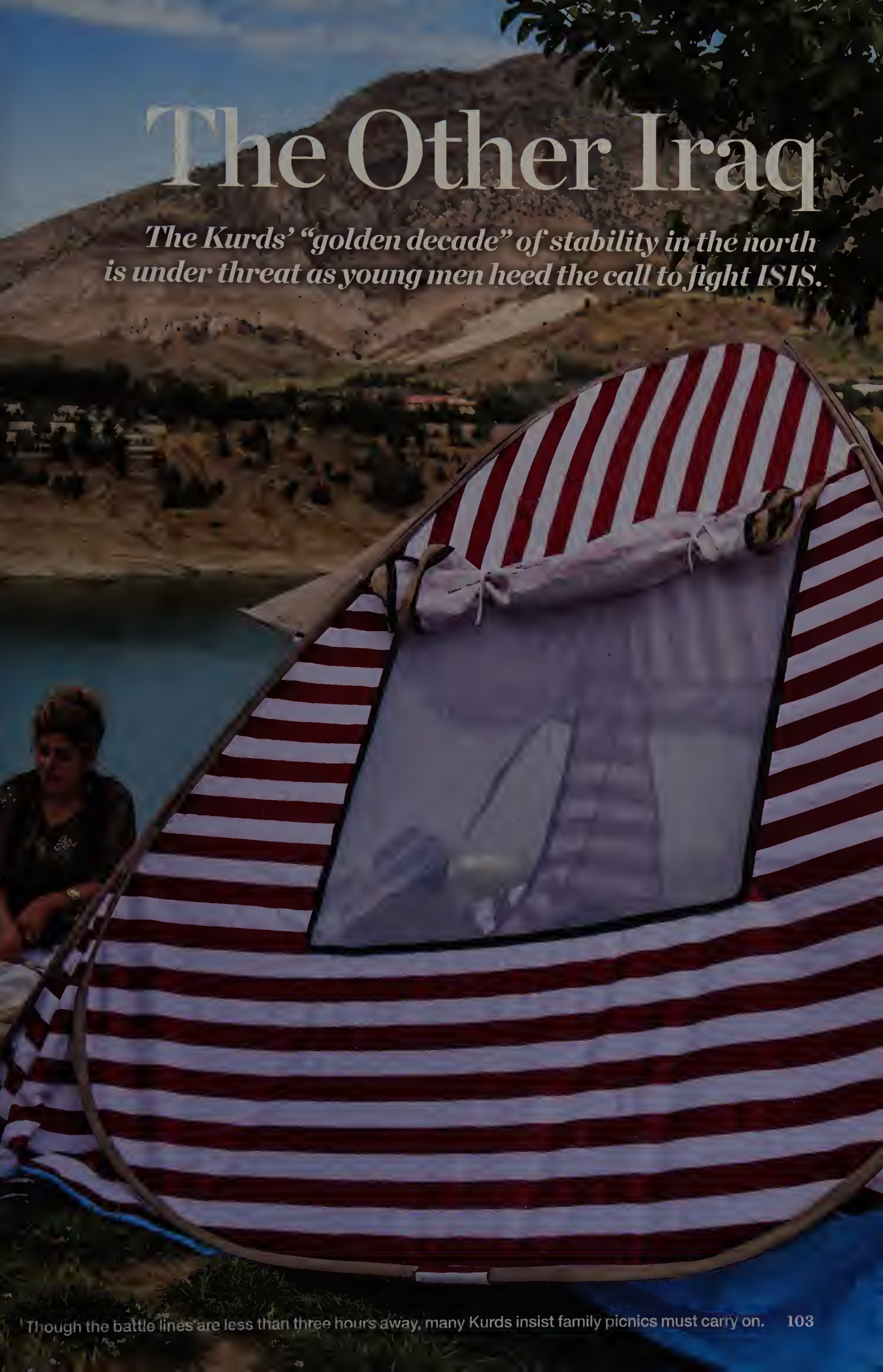
On a hillside in Victoria, Mahé's historic center, stands an unusual church clock that chimes twice—once on the hour, then again a few minutes later. I think of it as a metaphor for Seychelles: a second chime for a second chance, ringing out the rescue of robins, beetles, pitcher plants, and palms, a celebration of nature restored. □

Watch a video featuring Seychelles' native animals and the people working to protect them at *ngm.com/more*. Explore National Geographic's yearlong parks initiative at *natgeo.com/parks*.

By Neil Shea
Photographs by Yuri Kozyrev

The Other Iraq

The Kurds' "golden decade" of stability in the north is under threat as young men heed the call to fight ISIS.



Though the battle lines are less than three hours away, many Kurds insist family picnics must carry on.

A girl watches as a daughter (left), her mother (center), and sister-in-law are photographed with their faces concealed. The women are Yazidis, an ethnic Kurdish minority. The daughter and sister-in-law say they were forced to marry ISIS fighters before escaping to a refugee camp in Kurdistan. To get away, the daughter leaped from a second-floor window. "I didn't believe I would survive," she says.

South of Kirkuk, Kurdish troops called *peshmerga* play volleyball behind the front lines. When ISIS fighters, whose ranks are believed to include former Iraqi Army officers, began capturing Iraqi towns in 2014, the peshmerga proved one of the only forces able to stop them.

Young Kurds wear a mix of traditional and Western clothing to a graduation at the University of Sulaimani. This generation enjoys more freedom than previous ones. "We can study hard, but there is war," says one student. "Maybe all our work achieves nothing."

On the day that Mosul fell to ISIS, Botan Sharbarzheri decided he was willing to die.

The 24-year-old university student smiled as he left his parents' home in Slemani, a city in Iraqi Kurdistan, bought cigarettes, made a few phone calls. He and many of his friends were on summer break, so he had no trouble raising a group of like-minded young men, would-be warriors, eager and untested. Together, in a haze of smoke and text messages, they sketched out a plan. Questions arose and were quickly settled. Everything seemed clear, righteous. All agreed they would die for their homeland—not for Iraq but for Kurdistan. They would die to protect their families against a brutal enemy, just as their fathers had once done against Saddam Hussein's army. All they needed was a battlefield on which to prove themselves, a direction in which to charge.

Before the Islamic State (ISIS) tore into Iraq, Sharbarzheri had been restless, slouching toward an engineering degree. He stayed up too late. Never studied enough. Yawned at equations and statistics. Music was his love, and the oud, a relative of the guitar with a slender neck and a deep, round belly, his instrument. Some days he practiced the classical Middle Eastern scales, the *maqams,* for seven, ten, fourteen hours, his hand leaving the instrument only long enough to light another cigarette or lift a glass of tea.

Sharbarzheri played in public, joined musicians' clubs, dreamed of recording. But Iraqi Kurdistan's music industry is small even in prosperous times, so Sharbarzheri's father, a teacher, had long encouraged his son toward something more practical, like bridgebuilding. Sharbarzheri felt stuck. The Iraqi economy was crumbling, nothing looked promising. Another young man might have lowered his head and said, *eraadat Allah*—it's what God wants. But Sharbarzheri was fiercely secular, opposed to zealots of every kind. Until that week in June 2014, divine will meant less to him than forgotten homework.

And then the self-proclaimed army of God

arrived, burning and killing beneath a black banner and providing Sharbarzheri, suddenly, with purpose. He found in war a clarity he had known only in music. Every choice became a note: Link them well and he might write the score of his life. He owned no weapon, so he would sell his beloved oud to buy an AK-47. He had no training, so he would join himself to combat-hardened men. He had no girlfriend, so there was no one to stop him. His parents, had they known, would have tried—argued, wept, begged him not to go—but some things a man simply must do, and these are often the things he doesn't tell his mother.

MOST YOUNG KURDS had not expected another war. At least, not the one brought by ISIS. Only a couple of years before, Iraqi Kurdistan had been thriving. The Americans had deposed Hussein, the Kurds' most hated enemy, in 2003, opening the way for Kurds to establish control over their mountainous, Switzerland-size territory. Though they remained part of Iraq, they essentially created a protostate of their own. Investment, development, and oil-fueled optimism (Kurdistan sits atop vast oil deposits) were soon transforming the region. Skyscrapers rose over Slemani, the "Paris of Kurdistan," and Hewler, the Kurdish capital, attended by shopping malls, luxury-car dealerships, and gelato cafés. Universities were built. Something like universal health care was established. Promoters even dreamed up a slogan to lure tourists and businesses: "Kurdistan, the Other Iraq." And while Arab portions of the country seethed in those years, some five million Kurds entered what many call a golden decade. It was during this era—free of fear, fed on promises—that Botan Sharbarzheri came of age.

"Anything seemed possible," he told me. "At least for a while. You saw all these things happening. You saw everybody's life changing. I was just a kid, but still I could see it. My parents, everyone, felt relief."

I met Sharbarzheri early last year in a café in Slemani, where he'd returned to classes. He is short, handsome, often wears a thin goatee.

He limped, slightly, over to our table. Sharbarzheri had been shot while rushing forward in battle months earlier—a bullet clean through his calf—and many in the café had heard the story. Young men rose to greet him. Young women watched and whispered. In Kurdish culture there are few greater marks of honor.

"A strange thing is that I don't have to wait in lines anymore," Sharbarzheri said. And then the veteran blushed, changed the subject. He was making up exams for classes he'd missed during his recovery. They were going badly.

"I am having trouble putting my mind to it." He thumbed a string of traditional prayer beads as he spoke, though he insisted they held no holy purpose. "Engineering... It's just so boring."

Sharbarzheri was like most Iraqi Kurds—under 30 and generally hopeful about the future, though that hope was in steep decline. To him and many of his peers, the world was shrinking, flattening. ISIS was dangerous, but the militants were an outward threat.

Internally, Kurdish political parties, which had in the 1990s fought a vicious civil war, argued over power and money. Relations with Arab-dominated Baghdad, never solid, had been unraveling, and Arab leaders in the Iraqi capital had been withholding Kurdistan's portion of the federal budget in response to a dispute over oil revenues. The elation of the golden decade was draining away.

Sharbarzheri couldn't see the point of dull classes if ISIS might yet ruin everything. Or if the Iraqi state—corrupt, ineffective, and reeling—might collapse like a condemned house.

"It's better if we all die," he said, "than if we have to live this way much longer."

It was a particularly Kurdish way to put it. Most of the men in the café would have agreed, and probably many of the women, all of them wearing tight jeans and exuberant makeup, singing and clapping around a tall white

EXPLORER

Tune in Sunday, March 6, to National Geographic Channel's Explorer series episode *Fighting ISIS*.

Among Kurdish groups, those in Iraq are closest to independence. They have their own oil pipelines.

birthday cake. When you are young and taste freedom, how do you bear its loss?

Sharbarzheri had decided he would return to the front as soon as possible.

"In Kurdistan we are frozen," he said, reaching for cigarettes. "Nobody knows what to do. So I will keep fighting."

KURDS HAVE A DISTINCT culture and language, but except for a few historical moments of self-rule, they've always lived under the shadow and control of a larger culture—Persian, Arab, Ottoman, Turkish. Today some 25 million Kurds are believed to live in Syria, Iraq, Turkey, and Iran (though the true size of the population is unknown), and it's often suggested that they are the world's largest ethnic group without a nation. This may be true, but it hints at unity. There really isn't any.

From region to region Kurds speak different dialects and support hyper-local and often fractious political parties, and even if given the chance, they probably wouldn't try carving a greater Kurdish state out of those diverse lands. Part of the problem is that Kurds everywhere see themselves as underdogs, and they are often blinded by the tragic beauty of their own stories.

Among Kurdish groups, those in Iraq are closest to realizing independence. They have a parliament and president, oil pipelines of their own, and a military force called the *peshmerga,* which means roughly "those who face death." Remaining part of Iraq has long seemed a necessary evil—more a condition demanded by the West, and specifically the Americans, than a Kurdish desire. Every now and then in the years since Saddam Hussein's fall, the Kurdish government has hinted that it could secede from Iraq, and this enrages its powerful neighbors, Turkey and Iran, as well as Iraqi Arabs in the south. Yet Kurdish leaders always balk, frustrating many citizens, romantics all, who would rather have statehood than, say, peace or a functioning economy.

For the past several years, Western governments have relied on Kurds in Syria and Iraq to do most of the fighting on the ground against ISIS. Many Kurds will expect that effort to be acknowledged. Many will argue that they have earned their independence.

Countless times I've stepped into a cab only to have the driver immediately declare personal independence and claim kinship with America and Israel—a state beloved by numerous Kurds because it is small and relentless and surrounded, just as they are, by enemies.

"America, Israel, Kurdistan!" a man said to me recently. He held up three fingers, then drew them into a fist. "Together, we can win!"

"Win against what?" I asked.

"Everything!" His smile was magnificent. "And especially the Arabs."

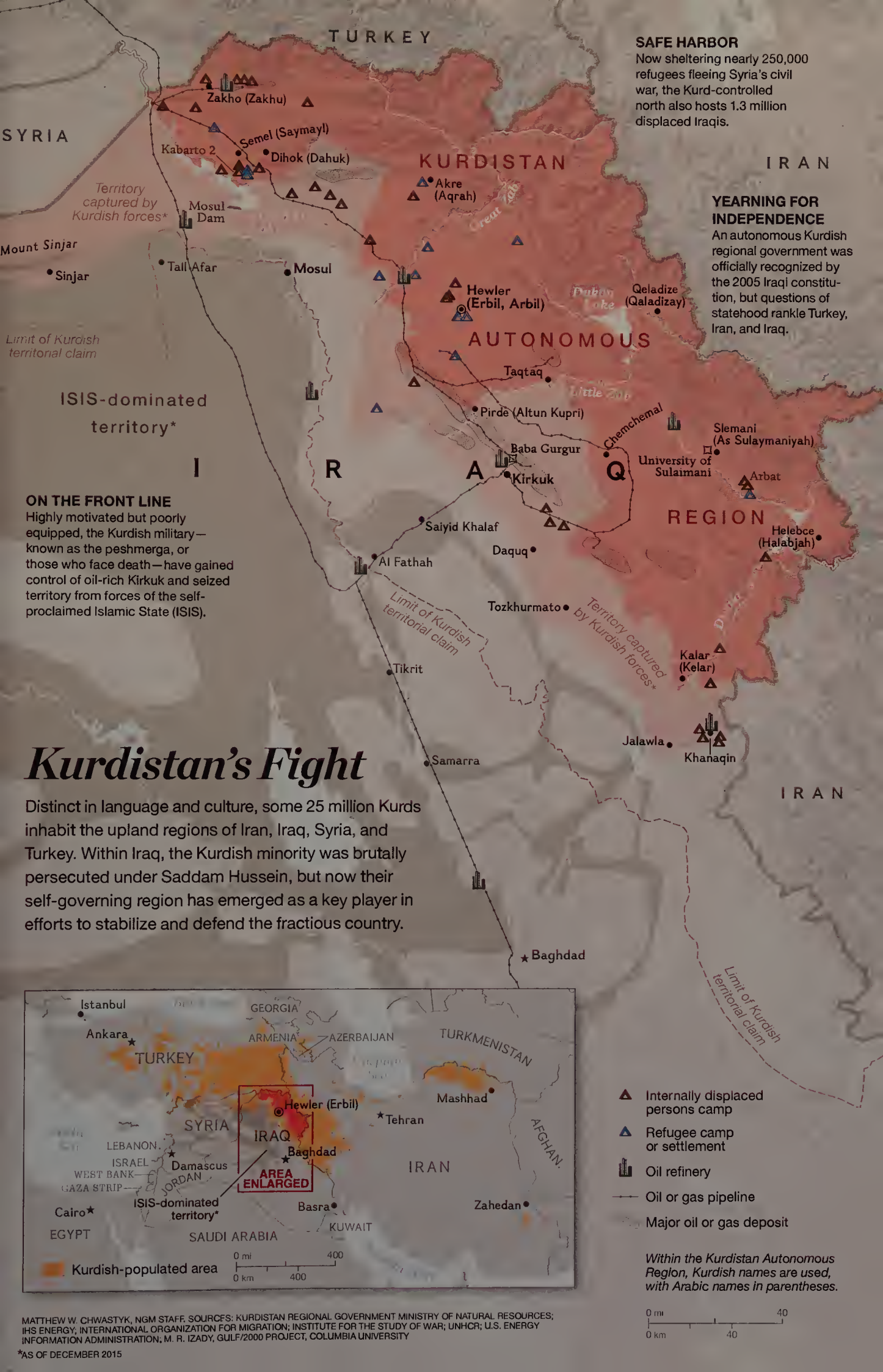
He told me he had served in the Kurdish resistance, battling Saddam Hussein. He saw no difference between that enemy and ISIS, which is said to include some of Hussein's former officers.

"Same, same," he said, wiping his palms together. He stepped on the gas and turned up the patriotic folk music. Our sedan-size state streaked through the enormous blue dusk.

ABOUT THE TIME Botan Sharbarzheri dropped out and chose war, another young Iraqi joined ISIS. Sami Hussein was 21 or 22 and lived in Kirkuk, a city less than two hours south of Sharbarzheri's university and that sits near Baba Gurgur, a major oil deposit.

He was a skinny Arab kid with a smudge of beard, impressionable in a way similar to Sharbarzheri, though it would pain either young man to hear me say that. Hussein's conversion to militant Islam may have begun with the whispers of a local cleric. He may, for a while, have even resisted the allure of the black banner. But there is almost no doubt that he felt despair about the future. The Kurds' golden decade may have flickered out, but most Iraqi Arabs had never experienced anything like that flowering in the years following the American invasion. In many places their lives had been far worse.

When I met him last spring, just after he'd been arrested, just before he vanished, Hussein said he'd joined the militants because he



SAFE HARBOR
Now sheltering nearly 250,000 refugees fleeing Syria's civil war, the Kurd-controlled north also hosts 1.3 million displaced Iraqis.

YEARNING FOR INDEPENDENCE
An autonomous Kurdish regional government was officially recognized by the 2005 Iraqi constitution, but questions of statehood rankle Turkey, Iran, and Iraq.

ON THE FRONT LINE
Highly motivated but poorly equipped, the Kurdish military—known as the peshmerga, or those who face death—have gained control of oil-rich Kirkuk and seized territory from forces of the self-proclaimed Islamic State (ISIS).

Kurdistan's Fight

Distinct in language and culture, some 25 million Kurds inhabit the upland regions of Iran, Iraq, Syria, and Turkey. Within Iraq, the Kurdish minority was brutally persecuted under Saddam Hussein, but now their self-governing region has emerged as a key player in efforts to stabilize and defend the fractious country.

MATTHEW W. CHWASTYK, NGM STAFF. SOURCES: KURDISTAN REGIONAL GOVERNMENT MINISTRY OF NATURAL RESOURCES; IHS ENERGY; INTERNATIONAL ORGANIZATION FOR MIGRATION; INSTITUTE FOR THE STUDY OF WAR; UNHCR; U.S. ENERGY INFORMATION ADMINISTRATION; M. R. IZADY, GULF/2000 PROJECT, COLUMBIA UNIVERSITY

*AS OF DECEMBER 2015

HCR
gee Agency

Outside his tent at the Arbat camp for displaced people, principal Mudhafer Abdul Nari prepares to oversee classes for hundreds of students. Waves of Iraqi Arabs have sought refuge in Kurdistan. "The Kurds have protected us," he says. "We feel safe."

The acting mayor of Jalawla tours his ruined city, near the Iranian border, where the peshmerga fought desperate battles against ISIS forces. Though the militants were driven out, residents can't return until hidden bombs are removed.

Masoud Barzani, president of the Kurdistan Regional Government, visits female officer cadets at a military academy in Zakho. Kurdistan remains part of Iraq, but it has its own parliament and its own military, which includes hundreds of female peshmerga.

believed Islam was under attack. He'd been won over by propaganda on Facebook and other social media and by the sermons of radical clerics. Like Sharbarzheri, he wanted adventure, with purpose, and he knew he'd end up fighting Kurds and fellow Arabs.

But while Sharbarzheri was an atheist, Hussein considered his choice a revelation of God's will, at least at first. It is also true that one cannot be lured to ISIS without being seduced by slaughter. There is no ISIS without murder, ruin, rape, and torture. Without a wrathful, merciless God. So where one young man went to defend, the other came to destroy.

When he left for battle, Sami Hussein apparently also had decided not to tell his mother. He was captured months later, as he sneaked home to see her.

KIRKUK, WITH ITS sun-crushed neighborhoods of Kurds, Arabs, Turkmens—and Sunnis, Shiites, and Christians—is Iraq in miniature. Centuries of diversity, love, beauty, and old grudges distilled there onto hot plains where the wheat fields meet the oil fields. In June 2014 the Iraqi Army abandoned the city, the possible resting place of the Old Testament prophet Daniel, ahead of an ISIS assault.

For the Kurds it felt like fate: They have long believed that Kirkuk was rightfully theirs, and Saddam Hussein had for years violently tried to evict them. That June, all the Kurds needed to reset their ancestral stake was to keep ISIS out, and their eager soldiers poured into Kirkuk to fill the breach.

It would not be easy. The speed of the ISIS invasion—and the collapse of the Iraqi Army before it—was astounding. The Kurds' own security forces were, at first, undermanned, ill equipped, and slow to adapt to the fleet enemy. ISIS fighters swept east and north, capturing Iraq's second largest city, Mosul, and killing more than a thousand civilians. Soon they had chewed into Kurdish territory and advanced to within a morning's drive of the Kurdish capital, Hewler (called Erbil in Arabic), and the outskirts of Kirkuk.

Kurds with means prepared to flee. Those without imagined the coming horror. But soldiers and volunteers, brave and disorganized,

At a checkpoint near the front line south of Kirkuk, an Arab woman pleads with peshmerga soldiers to allow her family entry into Kurdish territory. Over the past two years Kurdistan has absorbed more than a million people, prompting calls for immigration limits.

rushed to meet the militant wave. They threw up scattered defenses along a front line that curved for hundreds of miles along the Kurdish frontier, from the Iranian border in the southeast to the Syrian and Turkish borders in the northwest. Peshmerga forces sometimes arrived at battlefields in taxis, wearing tennis shoes and mismatched camouflage, carrying old and untrue rifles. Among those rushing forward was Botan Sharbarzheri.

By the time he made his way to Kirkuk, at the head of his unit of college-age volunteers, Western nations had backed up Kurdish forces with warplanes. That cover let the Kurds hold off ISIS fighters and then, in places, begin to push them back. Kirkuk was saved, for the moment, and the Kurds became one of the few forces capable of standing against ISIS.

Fighting still raged, however, outside of the city, in small, crumbling towns inhabited mostly by Arabs. Sharbarzheri's unit had been hastily trained and mostly held back from real combat. A firefight here and there, a few selfies taken beside the enemy dead. The young men of his unit said they were happy to cook, wash clothes, do anything for their fighting comrades, and it was true—though many also dreamed of proving themselves over more than just laundry.

Sharbarzheri's chance came during a chaotic drive into a village called Saiyid Khalaf, southwest of Kirkuk. His unit was behind the main peshmerga group, which was advancing slowly toward ISIS positions. A commander urged his men on, and Sharbarzheri, giddy, holding the rifle he'd bought with his oud, rushed forward behind the cover of an armored truck.

One of the ISIS fighters began firing beneath the truck at the legs of the attacking Kurds. A round spiraled through Sharbarzheri's calf and then burrowed into the leg of another peshmerga behind him, shattering bone. Both men fell, and the shooter might have fired again, finished them off, but his attention flicked to other targets. Sharbarzheri tried to stand but couldn't. He was dragged away, hurried into an ambulance, and soon the Kurds retreated.

Afterward, his parents visited him in the hospital. His mother cried. His father was so angry he couldn't speak. To risk everything, for

A Yazidi family holds photos of male relatives killed by ISIS as they tried to flee the town of Tel Azer, near Sinjar. "I hid under blankets and heard shooting," said one boy. "I came out and saw everyone—my uncles, father—dead." Only one adult male in the family survived.

what? For bravery? For patriotism? For a country that wasn't even a country?

But later his father, Mohammed, confided that even during his rage at the hospital he'd been achingly proud of his son. We sat together at a picnic at the family's home in Kurdistan's eastern mountains. Evening had come. Bats flitted over a blanket laid with roasted mutton, stuffed grape leaves, and loaves of fresh naan.

"We would all fight for Kurdistan," Mohammed said. "Even if we don't always believe in it."

THE DAY SHARBARZHERI WAS SHOT, Sami Hussein, the Arab who joined ISIS, was somewhere in the area. Possibly on the same battlefield.

I met him a couple of months later, the morning after he'd been captured during a police raid in Kirkuk, along with a half dozen other young men. At a police compound near the city center, Hussein was led into a narrow sitting room lined with couches. There was a scent of cologne, the stink of cigarettes. He came shoeless and sulking, stooped at the shoulders, wearing a yellow and gray plaid shirt and jogging pants. A policeman placed a small plastic table before him, set a cup of water there. Hussein appeared unharmed. Only his thumb was discolored—stained with the ink used to sign his confession.

A plainclothes detective led Hussein through a list of questions, many of which he'd already answered during an hours-long interrogation. Why did you join ISIS? Are there many foreign fighters among you? What do you do to the Yazidi girls you capture?

That question referred to ISIS's brutal treatment of members of a small Kurdish ethnic and religious group who are not Muslims—and whose fate at the hands of the militants has shocked the world. The detective asked this for my benefit, a reminder to an American of the terror Iraqis had been left to face alone.

"The fighters take the Yazidis and do anything to them," Hussein said flatly.

He told me he regretted joining ISIS, that its promises of glory and Islamic truth were empty.

"They're not Muslims," he said, shifting in his seat, staring at the floor.

If our roles had been reversed, Hussein might have enjoyed watching me beheaded. Might have done it himself. But now he was a

Revelers raise beers at Bar 52, a nightspot popular with foreigners, located in Hewler, Kurdistan's regional capital. The city has enjoyed an oil boom in recent years, attracting many expatriates. Some locals now complain there are too many bars and clubs.

bewildered kid, weary and barefoot. Soon the police commander, a Kurdish general named Sarhad Qadir, escorted me into a small garden where the rest of his night's catch knelt on bright green grass. They were blindfolded, their hands cuffed.

"What happens to them?" I asked the general.

"They go to prison," he said vaguely, waving a hand. "What happens next is not up to me."

There is a rumor, persistent, difficult to ignore, that Kurds and Arabs routinely execute their ISIS prisoners. I asked my translator about it as we left the police compound.

"What happens to the kid?"

"He will be executed, of course."

"How do you know?"

"Why do you care, man? He's ISIS."

Really, I was thinking of Hussein's mother, wondering if she would ever see her son again.

FOR A FEW WEEKS, I tried following Hussein's trail. I asked policemen, peshmerga commanders, politicians, lawyers, even the Kurdish prime minister. No one could—or would—offer any clues.

For a while, I became obsessed with his case. It wasn't exactly sympathy—hard to feel that for an ISIS volunteer. But his story contained all the problems facing Kurdistan, Iraq, the Middle East—the questions of how to build and become a functioning nation, win the support of neighbors, and keep those at home, whoever they are, from falling, turning, and coming against you.

Hussein was just one among tens of thousands who'd flocked to ISIS, and when I couldn't find him, I went looking for others. Many ISIS fighters in Iraq are Iraqi citizens recruited or conscripted from ISIS-held territory. Most are Sunni Arabs, though young Kurds have also gone to the group.

In the city of Qeladize, in Kurdistan, a man named Salah Rashid told me of his 18-year-old brother-in-law, Hemin, who'd joined ISIS in 2014. The young man had been drifting, untouched by Kurdistan's golden decade, unable to find solid work. Slowly, he'd become radicalized by a local imam, also a Kurd, who lectured on holy war, martyrdom, and paradise.

Hemin and several others followed the man's

A man takes time for afternoon prayers during an outing at Dukan Lake, a popular vacation spot in Kurdistan. Most Iraqi Kurds are Sunni Muslims, and they retain a culture and language distinct from that of their Arab, Persian, and Turkish neighbors.

Even if given the chance, they probably wouldn't try to carve a single Kurdish state out of the lands they claim.

sermons into Syria, where they hoped to fight the forces of dictator Bashar Al-Assad. But ISIS leaders soon ordered Hemin and his friends back to Iraq to fight against their own people.

Rashid tracked his brother-in-law's movements in phone calls and on Facebook, and he came to believe that Hemin was unhappy. He hadn't enlisted to fight Kurds, and he no longer seemed to believe ISIS's propaganda. Hemin was killed in October 2014 in the town of Sinjar, which had fallen to ISIS (and was recaptured by peshmerga forces late in 2015). Rashid was told that Hemin died in battle, but he's never believed that.

"We think he was going to leave Daesh," he said, using a common Arabic name for the group. "You see, there was no fighting in Sinjar the day he died. I think he wanted to come home, and they killed him."

Rashid begged ISIS commanders to let him have Hemin's body. They refused, leaving his family to ponder a few last photographs on Facebook that showed a pudgy, bemused boy in borrowed camouflage.

"Hemin was a big kid," Rashid said. "A lot of boys are joining Daesh not because they are extremists, but because they have not found themselves. I blame myself for not taking better care of him. God knows what will happen to him now."

Rashid was talking about the afterlife, where, he assured me, Hemin would find no paradise.

On the drive back to Slemani, I thought of Sami Hussein. At best he was locked in a cell somewhere. Possibly he was counting out the last days of his life.

The following week I showed Botan Sharbarzheri a photo I'd taken of Hussein. He took my iPhone and stared at the ISIS volunteer.

"I hate him," Sharbarzheri said. "He makes me think of revenge. I will get my revenge. For what they did to me and what they did to all of us. I promise you."

It was a very Kurdish way to put it.

DURING MY LAST VISIT to Iraqi Kurdistan, in October, I searched again for Hussein. The police general who'd arrested him could not remember his name, and the Iraqi justice system remained as opaque as ever. I thought I might simply go door-to-door through Kirkuk's Arab neighborhoods, showing his photograph, but it was a risky plan, and my translator warned that we might endanger anyone who spoke to us. So Hussein had vanished, at least to me. One more ghost among the thousands who've gone missing in Iraq over the past 10 years, the past 50.

Away from the front line, my Kurdish friends had all grown wearier, gloomier. The peshmerga continued pushing ISIS back in several places, but elsewhere the Iraqi Army foundered. Major cities such as Mosul and Ramadi still smoldered under the militants' control, and the Iraqi economy (and with it the Kurdish one) coughed along, dragged down by low oil prices and years of war. The bloodied country seemed to be no closer to reconciliation, and within Kurdistan old wounds ached, while new ones worsened.

In several Kurdish cities and towns, protests flared that month. Many were peaceful—schoolteachers, for example, who demanded wages they hadn't been paid in months. But other protesters sought political reform, and some of those demonstrations had turned violent, even deadly. In Slemani policemen in black riot gear ringed the central bazaar, and peshmerga units were recalled from the front to keep order. At night military convoys snaked through the city.

Sharbarzheri himself seemed optimistic, despite the unrest. He'd recently returned to school full-time, and switched his major from engineering to international studies. Someone had given him a new oud, more beautiful than the last, and though he still kept an AK-47 in his bedroom, half forgotten, wedged in a closet between some blankets, he no longer thought of returning to war.

"Politics is the only way to make any changes," he told me.

I must have laughed, because he suddenly became quite serious.

Peshmerga returning from the front line wait for a lift on the outskirts of Hewler. Behind them looms a skyline of unfinished buildings, a reminder of a more hopeful era. "We haven't been paid in months," says one soldier. "It doesn't matter. We would all die for Kurdistan."

"Really. It's true," he said. "In Kurdistan you can do nothing outside the political parties. So that is my next fight."

We were walking down Salim Street in Slemani, where on almost any fair night the streets overflow with young Kurds, mostly men, who parade up and down, drinking tea, playing pool, eating, laughing, and texting till morning.

The streets were strangely quiet. Men pushed carts loaded with pomegranates, looking for customers. I noticed the squeak of the wheels, the whine of a cat. No crowds to shoulder through, no heavy clouds of cigarette smoke. I asked Sharbarzheri about it. Figured it was the weather, maybe a football match.

"So many have gone," he said, and I thought he meant home.

"No, to Europe. They have become refugees. They go to Turkey, then try to get to Greece, or somewhere. Then to Germany. Everyone wants to leave."

"Why?"

"Everybody thinks Iraq is *tawaw,* finished. And they don't believe in Kurdistan anymore. With ISIS, with the economy being crap, they don't see opportunities. I know so many guys who've gone."

I imagined the crowded camps, the chaos in Europe as streams of hopeful migrants poured in. Many Kurds, if they survived the journey, would join family already living on the continent. The exodus had begun years ago. It was simply picking up pace.

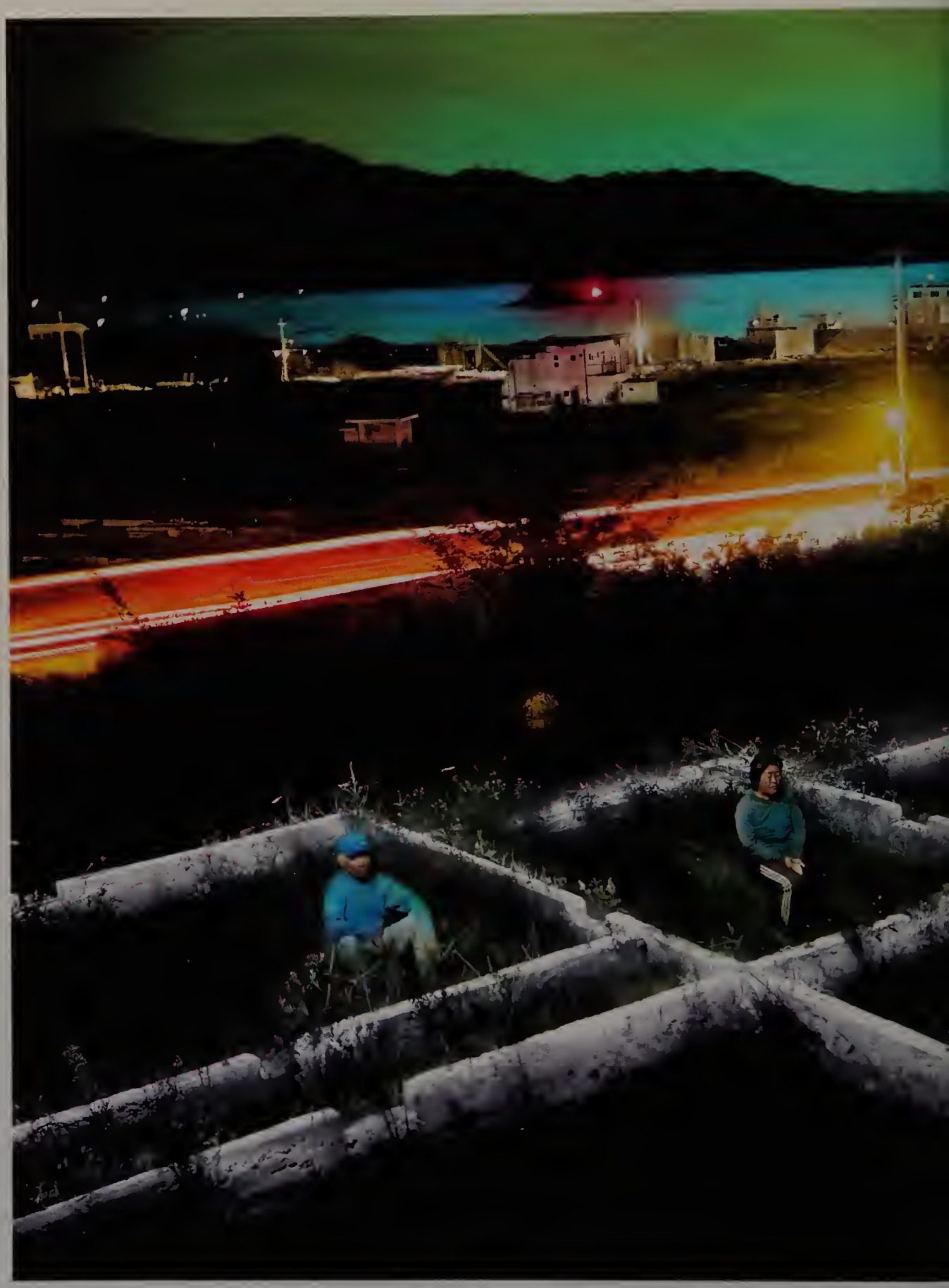
"And you?" I said. "You'll stay?"

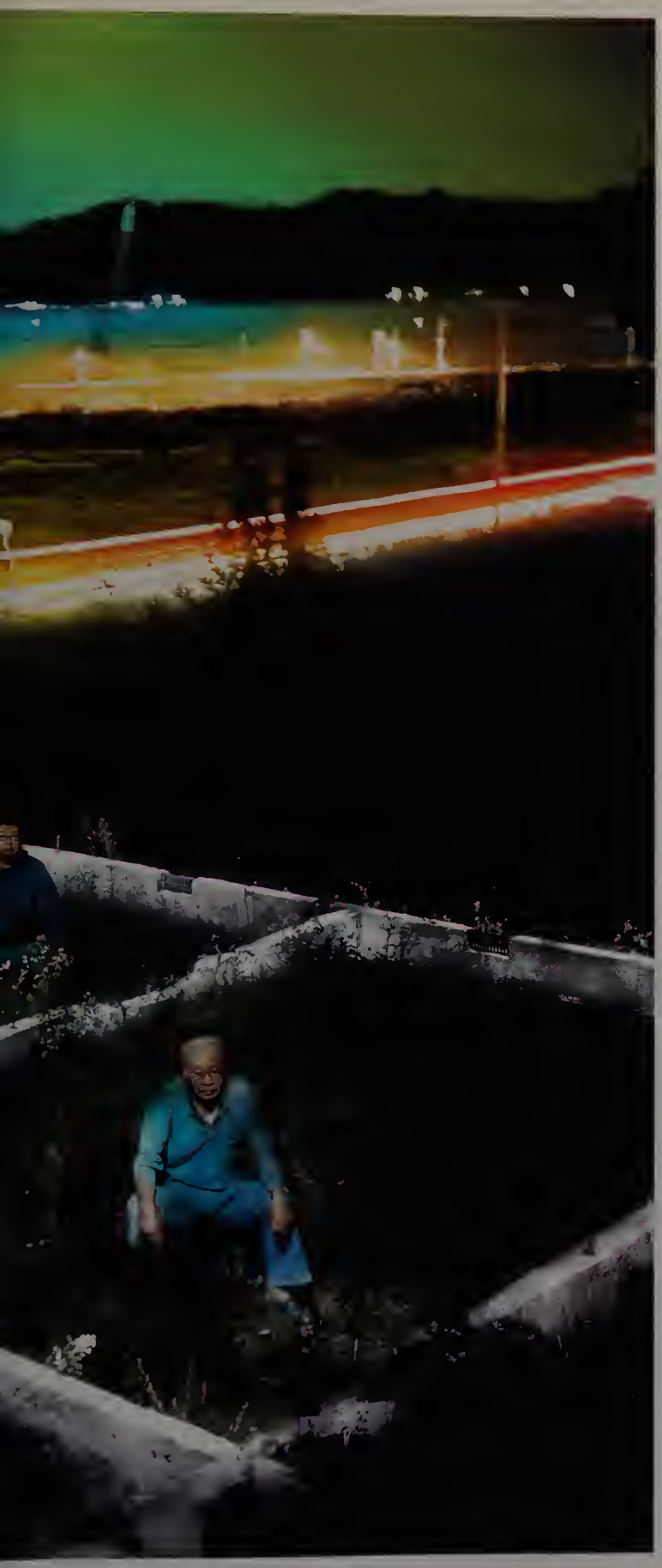
Sharbarzheri smiled. "Yes. I am that kind of Kurd. I'll never leave." ▯

STEPHEN ALVAREZ

A frequent *National Geographic* contributor, **Neil Shea** wrote about Kenya's Lake Turkana in the August issue. You can follow him on future reporting assignments on Instagram: *@Neilshea13.*

What surprised you during your fieldwork? I was amazed at the fragility of the idea of Iraq. Not many Iraqis—whether they're Kurds, Arabs, Turkmens—think the country can last. For them, Iraq was never a real nation. It was always a dream cobbled together by Western powers.





Tsunami Memories

By **JEREMY BERLIN**
Photographs by **ALEJANDRO CHASKIELBERG**

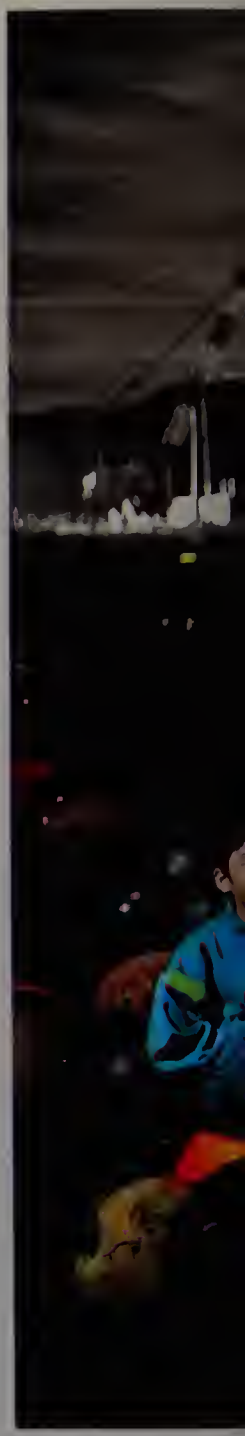
Five years ago a massive earthquake struck off the eastern coast of Japan. The tsunami it unleashed destroyed large swaths of the island nation, killing nearly 16,000 people, causing $200 billion in damages, and roiling the lives of those who survived.

One of the hardest hit places was Otsuchi, a small fishing community on the northeastern edge of Honshu, Japan's largest island. When the floodwaters receded, its population had been decimated and displaced.

Alejandro Chaskielberg arrived in Otsuchi in October 2012. The Argentine photographer had heard about the town from a friend with relatives there, and he hoped to document the devastation. That included "mountains of debris" dotted with red flags where bodies had been discovered.

"I decided to photograph in black and white," he says, "because I thought, This is extremely sad. Other than the flags, there are no colors left here." But when he found a waterlogged family photo album lying in the street, he was startled to see the colors that had smudged and

In Otsuchi, Japan, family members sit in what's left of their home—one of many residential buildings razed by an earthquake-born tsunami in 2011.



blended together. Those saturated hues, he thought, were colors created by the tsunami.

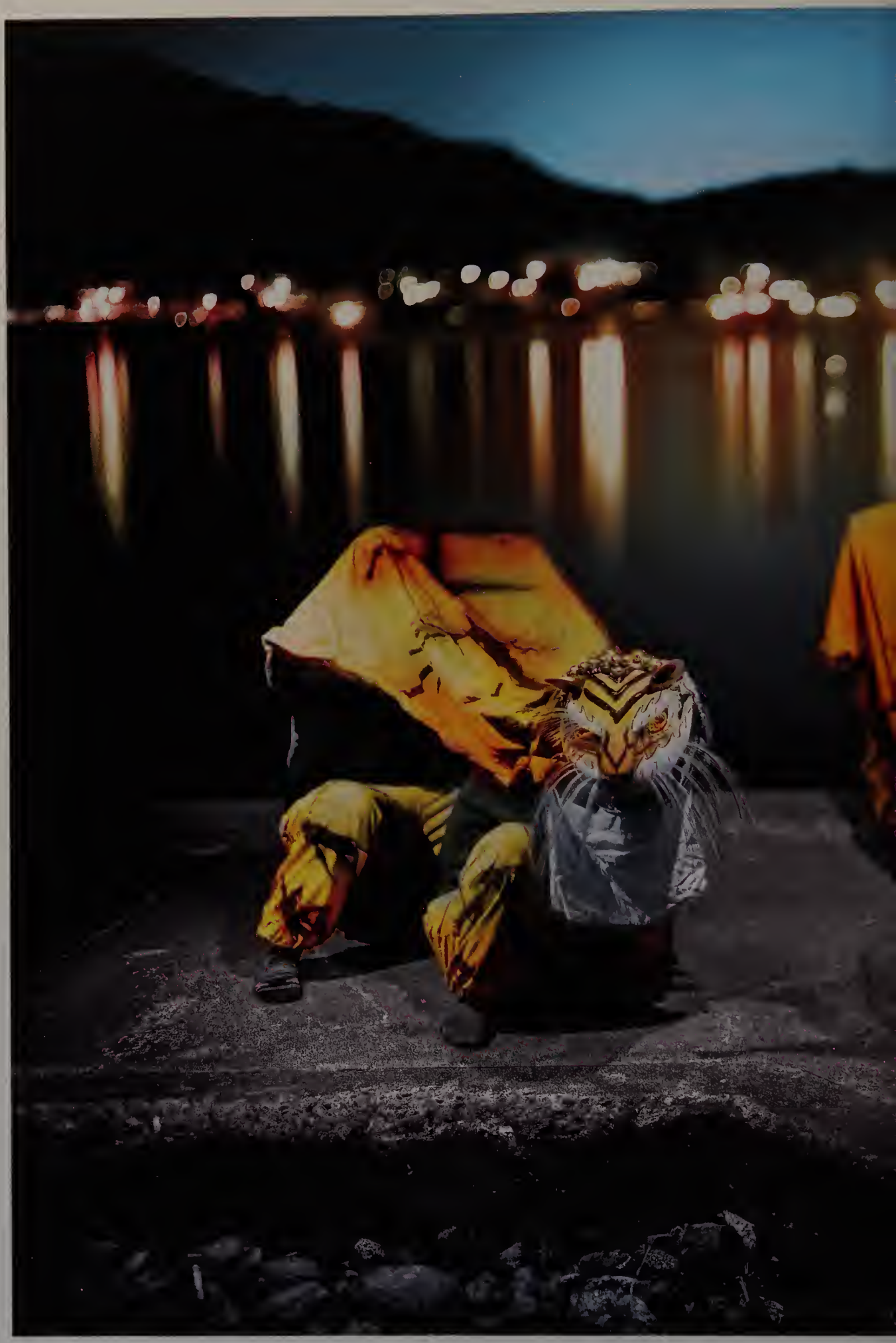
With that palette in mind, Chaskielberg began to turn tragedy into tableau. He asked residents to pose at night, silent and motionless, in the ruins of their old homes or workplaces. Many were wary at first. But after he staged a photography workshop for local students and brought his four-month-old daughter to Otsuchi, he began to win their trust. His project eventually became part of the town's rebuilding process.

Chaskielberg illuminated his subjects with moonlight, streetlights, and flashlights, then used long exposures to make the black-and-white photographs. Later, after scanning the negatives, he tinted the images in his digital darkroom to match the vivid colors of the photo album.

The results, he says, are solemn and intimate—meditative "attempts to recover memories and bridge the past and the present. Family photographs are part of our memories, part of our identities. These people lost all that in the tsunami. So this was a way to help them create new memories."

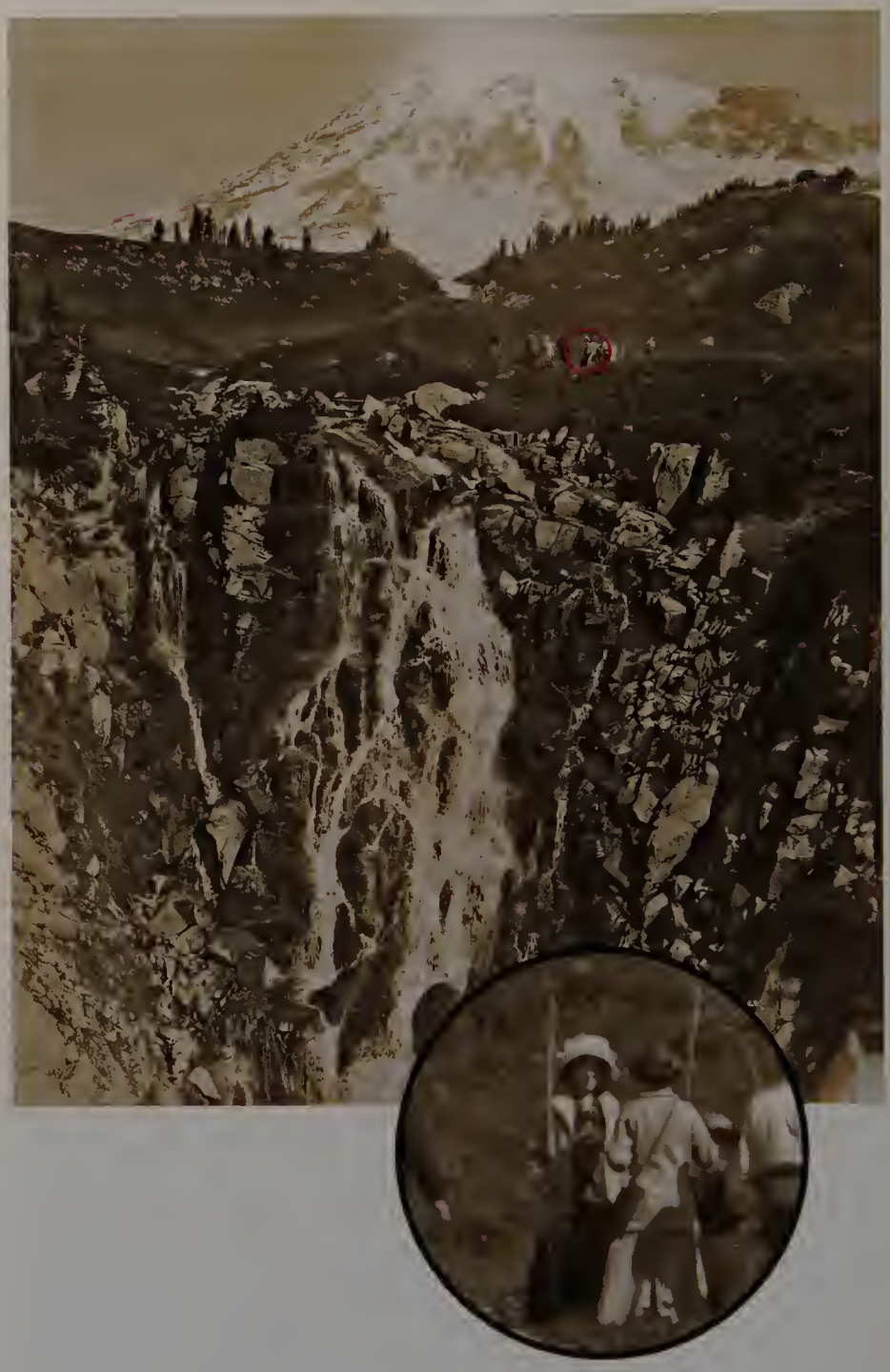
It's an approach, he adds, that's as portable as it is helpful. "I want to show how we can use photography to rebuild our lives," he says. "Not just with this atrocity, but every time an atrocity like this happens." ▯

On his first trip to Otsuchi, photographer Alejandro Chaskielberg asked Koichi Miura (second from left), Takanobu Sasa (second from right), and their relatives to pose in the town's ruined port, where they used to dry and package fish. On his second trip, he and a group of aid workers recovered hundreds of blurry images from the debris (top left).



Sitting on the dock of Otsuchi Bay, members of a local preservation society wear tiger costumes—part of a traditional dance performed here each year as a prayer for a good fishing season. When the tsunami struck in 2011, water swept over a 21-foot-high seawall, washing away one bridge and damaging another. Many residents lost their livelihood to the waves. Today Otsuchi is starting to recover, but reconstruction won't be complete for several more years.

Three years after the disaster, five surfers at Kirikiri Beach—(from left) Satoshi Tsuchizawa, Kei Sugimoto, Hiroshi Sugimoto, Yuya Miura, and Rieko Sugimoto—stand near a protective barrier that was ravaged by the tsunami. To create these intimate nocturnal portraits, Chaskielberg asked locals to pose where they used to live, work, or play. "I wanted to set up a spiritual moment for them," he says. "It was something I could feel, taking these pictures."



Mount's Majesty

Surrounded by stunning sights—Mount Rainier in the background, Myrtle Falls at the fore—the visitors in this picture might be overlooked. But there they are, in full dress, carrying walking sticks and touring the Paradise area of Washington State's Mount Rainier National Park.

This undated photo, likely shot a decade or so after the park's 1899 founding, is credited to photographers Asahel Curtis and Walter Miller. Curtis was devoted to Mount Rainier: He photographed it thousands of times and helped form the Mountaineers, a climbing club dedicated to the area's preservation. His papers, archived at the University of Washington, include this reflection: "The trivial things of life; the petty cares that to us seem so great slink back in the presence of this majestic mountain." —*Eve Conant*

PHOTO: CURTIS AND MILLER, NATIONAL GEOGRAPHIC CREATIVE

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